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Notes on the Salamanders of the *Ambystoma gracile* Group

By Emmett Reid Dunn

THE *Ambystoma gracile* group differs from other species of *Ambystoma* in the presence of a premaxillary fontanelle (as in *Dicamptodon* and in *Rhyacotriton*) and in usually having three (instead of four) phalanges in the fourth toe (again as in *Dicamptodon* and *Rhyacotriton*). From other members of the family they differ in having a much more developed parotoid gland. As they have the tongue structure of the *maculatum-tigrinum* group of *Ambystoma* (dorsal part of otoglossal rod-like and transverse, plicae radiating anteriorly from it), they are more nearly allied to them than to *mabeei* (dorsal part of otoglossal with median anterior projection, plicae radiating laterally from it), or to the members of the *texanum* group (tongue structure as in *mabeei*, plus elongated body and highly specialized dentition).

The range of the *gracile* group, the northwest Pacific coastal area, is shared with *Dicamptodon*, with *Rhyacotriton*, and with two species (*tigrinum* and *macrodactylum*) of the typical group of *Ambystoma*. More precisely, I have examined specimens of this group from an area delimited to the south by Ft. Bragg, Mendocino County, California (UMMZ), to the north by May (or Mary) Island, Alaska (USNM), and to the east by the Cascade Mountains (USNM and Roy. Ontario Mus.).

Three systematic names have been based on specimens of this group. I have examined all the types:

Siredon gracile Baird, Expl. Surv. RR. Miss.-Pac., 10, 1857, Williamson and Abbott, No. 4: 13, pl. 44, fig. 2. Cascades at lat. 44° N. (USNM 4080).

Amblystoma paroticum Baird, in Cope, Proc. Acad. Nat. Sci. Philadelphia, 19, 1867: 200. Chiloweyuck Lake, British Columbia (USNM 4708a).

Amblystoma decorticatum Cope, Proc. Amer. Phil. Soc., 23, 1886: 522. Port Simpson, British Columbia (USNM 14493).

Including the types of these three described forms, I have examined the following material of this group: seven from California, 7 from Oregon, 52 from Washington, 19 from Vancouver Island and the adjacent mainland of British Columbia (south of lat. 51°N), 19 from British Columbia and Alaska (north of lat. 51°N), total 104. The name applied earliest, *gracile*, was based on a larva. The adults can be divided into two forms, not well differentiated, which I consider races. The line of demarcation between these races is somewhere about lat. 51°N. The southern race should be called *Ambystoma gracile gracile* Baird (with *paroticum* Baird as a synonym), and the northern race should be called *Ambystoma gracile decorticatum* Cope.

The northern race, in its most extreme development of characters, differs from the southern as follows:

a. Four (instead of three) phalanges in the fourth toe.
b. Parotoid less well developed.
c. Pepper-and-salt coloration of light dots on dark background (instead of uniform dark).
d. Teeth on prevomers in two groups, behind and between choanae (instead of four groups, two as above and two posterior to and beyond

choanae). Also the two median groups are shorter in the northern race than in the southern.

As the northern specimens show all possible combinations of these characters and their opposites I think that they do not represent a distinct species. On the other hand these characters are manifested only in northern specimens, and therefore I think that a northern race may be recognized.

The following list of localities from which I have examined specimens indicates the range of the *decorticatum* population. ALASKA: May (or Mary?) Island, lat. 54° 30′. BRITISH COLUMBIA: Bella Coola, Chillinae Valley on Tamitly Mt., Hagensborg, Hunter Id., Matlakatla, Porcher Id., Port Belmont, Port Simpson, Prince Rupert, and Spider Id. (lat. 51° 50′).

While some of these have been recorded in the literature as *gracile* (or as *paroticum*), such records only indicate that (as in many geographical races) some specimens are difficult or impossible to allocate. I think that I have examined all the specimens mentioned in literature from north of lat. 51°.

I here list Canadian localities for specimens examined that I refer to *gracile*. Here again I think that I have examined nearly all the specimens mentioned by other authors. BRITISH COLUMBIA (mainland): Brent's Lake, Chiloweyuck Lake (= Chilliwack Lake), Hollyburn Ridge (just N. of Vancouver), Nita Lake (36 m. N. of Squamish at lat. 50° 10′) and Vancouver. VANCOUVER ISLAND: Mt. Arrowsmith, Nanaimo, Quatsino, Ross Lake (9 m. NW. of Victoria), and "Vancouver Id."

I add only a partial list of localities in the United States. For Washington, reports exist from at least ten of the eighteen counties west of the Cascades, and I have seen material from five of them. A 216 mm. long male from Forks, Clallam County (Coll. Puget Sound 1099), is the basis for the record of *decorticatum* by Slater (COPEIA, 1930: 87). Professor Slater has recently been so kind as to lend me this specimen for comparison with the Provincial Museum material. The vomerine teeth are in four patches, there are three phalanges on the fourth toe, the parotoids are well developed, and the color (in its present somewhat faded condition) is much more like that of the southern than of the northern race. At present I consider it a member of the southern race, but additional fresh material might indicate an Olympic Mountain race. From Oregon I have seen material from Clatsop, Hood River, and Lane counties and it has been recorded from Marion County. From California I have seen material from Mendocino County (Fort Bragg, UMMZ) and from Siskiyou County (Sisson, AMNH). It has been recorded from Humboldt and Del Norte counties.

While the division of the two races is on the basis of adult characters, I have noticed the northern larvae have the belly very slightly pigmented, and have two rows of light dots on the sides, an upper row with one dot to every other costal fold and a lower row with a dot to every costal fold. The southern larvae have the belly quite heavily pigmented, and the rows of light dots are not apparent.

I owe especial thanks to the authorities of the Provincial Museum, Victoria, for the recent loan of their salamander material.

HAVERFORD COLLEGE, PENNSYLVANIA.

Description of a New Snake from Mexico

By Hobart M. Smith and Wilmer W. Tanner

THE discrimination of a new species of snake of the genus *Leptodeira* is made possible by a specimen in the Museum of Vertebrate Zoology at the University of California, collected in southeastern Sonora, which makes the thirteenth form of *Leptodeira* recorded from Mexico. The range of the genus, which reaches the Brownsville region in Texas on the Gulf coastal plain, is thus extended northward on the Pacific slope of Mexico to Sonora. The fauna of the Alamos region in that state, with this addition, proves to have southern affinities unsuspected until recently. Other recent additions to the list from that locality include the lizards *Sceloporus nelsoni* and *Urosaurus bicarinatus tuberculatus*, whose ranges are strikingly like that of the new *Leptodeira*. It seems evident that the Neotropical Region should be regarded as extending northward along the western slopes of the Sierra Occidental to include extreme southeastern Sonora.

In reference to the rather large, broad dark dorsal blotches we name the species

Leptodeira ***ephippiata,*** sp. nov.

Type.—Museum of Vertebrate Zoology No. 28931, a small female from Agua Marín, 8.3 miles west northwest of Alamos, Sonora, collected by C. Sibley on May 5, 1939. *Paratype:* U. S. National Museum No. 46459, an adult female from Plomosas, Sinaloa, collected July 19, 1897, by E. W. Nelson and E. A. Goldman.

Diagnosis.—Three preoculars; dorsal spots on body 24 to 32, reaching 2nd scale row; ventrals 180 to 182; scale rows 21–17; nuchal blotch not strongly notched anteriorly, continuous with a dark median longitudinal nape streak; a distinct postocular dark stripe not clearly continuous with nuchal blotch; allied to *bressoni,* but with fewer and broader blotches, and to *splendida,* but with more blotches and more ventrals.

Description of Type.—Head distinct; snout blunt; top of head flattened; body cylindrical. Rostral barely visible from above, broad but very short, actual width 2.2 mm., height 1.1 mm.; internasals a little more than ⅓ size of prefrontals, their median suture little more than ½ length of suture between prefrontals; latter extending onto sides of head; frontal 5-sided, the lateral edges somewhat concave, a third longer (3.3 mm.) than broad (2.4 mm.), a little longer than distance from tip of snout (3 mm.), subequal to length of median suture between parietals. Nasal divided below and perhaps above also, posterior section a little larger and higher than anterior, and naris pierced in anterior section; loreal somewhat longer than broad; 3 preoculars, upper largest and broadly separated from frontal, lower smallest; 2 postoculars, upper nearly twice as large as lower; a large anterior temporal, but preceded on one side by two small scales, and on the other bordered above at anterior edge by one small scale; two posterior temporals. Supralabials 8-8, 4th and 5th entering orbit, 7th highest, 8th longest, 2nd smallest; infralabials 10-10, 5 in contact with anterior chinshields, 5th and

6th with posterior chinshields; latter a little longer than but about as broad as anterior chinshields, in contact anteriorly but diverging posteriorly; one scale on one side, two on other, between chinshields and 1st ventral. Scale formula

$$\begin{matrix} 109 & & 132 & & 182 \\ \left[\begin{matrix} 9+10 \\ \hline 9+10 \end{matrix}\right] & 19 & \left[\begin{matrix} 8+9 \\ \hline 8+9 \end{matrix}\right] & 17 & \\ 109 & & 131 & & 182 \end{matrix}$$

Dorsal scales with paired apical pits, smooth except for a few, weakly keeled, in the vicinity of the anus. Anal divided; subcaudals 81, divided.

Total length 256 mm.; tail 62 mm.; tail/total length ratio 25.2%; head length 12.9 mm.; head width 8 mm.; length of eye 2.1 mm.; distance from orbit to naris 2.4 mm.

Counting on either side, there are 24 dorsal crossbands or blotches involving all except the 1st scale row; the blotches are brown, darker along anterior and posterior margins; along the median line they cover an average of about 5 scale lengths, widening toward either side; laterally the blotches are rather truncate, not rounded, and not sharply defined. In three areas the dorsal blotches are split or staggered along the median line and are irregularly fused; for the most part, however, the blotches are regular, transverse dorsal bands. Spaces between blotches are lightly stippled, less so near edges of blotches, involving some 3 scale lengths on median line. A series of small, poorly defined lateral spots alternate with the larger blotches, involving primarily the 2nd row but also the 1st and 3rd. The blotch on the nape is single, concave anteriorly, but not deeply notched as in *bressoni;* a narrow median longitudinal dark nuchal stripe extends from posterior part of parietal to the nuchal blotch. A dark postocular stripe, broadening posteriorly and practically disappearing on secondary temporals and last labials, is continued as a narrow, very vague streak to the lateral margin of the nuchal blotch. Irregular dark markings are present on the top of the head.

The tail has 14 (13) blotches, involving all the dorsal scale rows. The ventral surfaces are white, the dorsal pigment involving the extreme lateral edges of the ventrals, which are very lightly stippled. The lower labials and anterior chinshields are stippled.

Maxillary teeth 16 + 2; anterior series decreasing in size anteriorly; last two teeth much larger than any preceding tooth (nearly twice as long), very close together and oblique with reference to the maxillary teeth; both fangs deeply grooved on anterior margin; a diastema preceding fangs, about as long as the space occupied by two preceding teeth. Palatine teeth 10, similar to maxillary teeth, last smallest, all nearly equal in size and nearly as large as anterior maxillary teeth; palatine toothed to tip. Pterygoid teeth 27, markedly decreasing in size posteriorly, anterior (largest) about equal in size to smallest maxillary (anterior) tooth; a long, fine, toothless posterior ridge on pterygoid, almost exactly ⅓ the total length of the bone. Ectopterygoid broad and deeply notched anteriorly, slender posteriorly. Dentary teeth 20, decreasing in size posteriorly, largest about equal in size to smallest maxillary teeth.

VARIATION.—The single paratype has 10–11 infralabials; the temporals are normal, 1–2. Scale formula

$$21\text{–}21\ \begin{matrix}111\\ \left[\begin{matrix}9+10\\ \hline 9+10\end{matrix}\right]\\ 110\end{matrix}\ 19\ \begin{matrix}132\\ \left[\begin{matrix}8+9\\ \hline 8+9\end{matrix}\right]\\ 131\end{matrix}\ 17\ \begin{matrix}180\\ \\ 180\end{matrix}$$

Subcaudals 78. Total length 540 mm., tail 131 mm. Dorsal spots more rounded laterally and not expanded toward either side, reaching 2nd or 3rd scale row, 32 (33) on body, 19 (±) on tail. Light spaces on back more heavily stippled than in type, indicating that in this as in several other species the degree of pigmentation of the ground color increases during life. Otherwise much as in the type.

RELATIONSHIPS.—Obviously the closest relatives of *ephippiata* are *bressoni* and *splendida*. The former differs by having more numerous blotches (32 to 38 or more) that tend to be broken medially, are rather rounded, and do not extend laterally beyond the 5th scale row; the very characteristic nuchal blotch with a very deep anterior notch, and the usual separation of the median nape stripe from the nuchal blotch, are lacking; and the ventrals are less numerous in known specimens (168 to 177 as against 180 to 182). *L. splendida* differs by having fewer spots (19 to 23 as against 24 to 32 on body) that reach only to the 3rd or 4th scale row, and in having fewer ventrals (165 to 168 as against 180 to 182).

The maxillary teeth of all three species are much the same; a specimen of *splendida* (EHT–HMS No. 5179) has 16 + 2, as does a single specimen examined of *bressoni* (EHT–HMS No. 5173). The palatine teeth are about the same also, *splendida* with 10 and *bressoni* with 11. The pterygoid teeth are perhaps less numerous in *ephippiata* with 27, as against *bressoni* with 28 and *splendida* with 30. The dentary teeth are 23 in both the latter species, but the apparent difference of 3 may not be real, since the posterior tip of the bone appears to be broken off in a prepared jaw of *ephippiata*. The greatest difference observed in the biting apparatus is in the proportion of the length of the posterior toothless part of the pterygoid to the total length of the bone. In *splendida* it is only ⅕ the total length, and in *bressoni* it is ⅔ the total length. In *ephippiata* the toothless portion is notably longer, involving ⅓ the length of the whole bone. Thus the small difference in pterygoid tooth count may possibly have more significance than might otherwise be supposed.

An apparent difference in the relation of the frontal length to its distance from tip of snout, evident upon comparison of descriptions, does not exist. In *bressoni* as in *ephippiata* the frontal is a little longer than its distance from the tip of the snout; an injury in the type of the former accounts for the apparently shorter frontal.

The new species resembles *Hypsiglena* so much in coloration that it was referred to that genus by the senior author and sent to the junior author for his studies on *Hypsiglena*. The paratype from Sinaloa had been referred to *Leptodeira bressoni* by Taylor (1939: 324).

The above three species and *punctata* together form a compact group

which apparently is represented in Central America by still another species, *rhombifera.* The group is characterized by having distinct dark marks on head and nape, generally 3 preoculars, and ventrals 149 to 182; the scale rows are 21(19)–17, the subcaudals 70 to 90, and the body rhombs 19 to an indefinite number. This group is the only one in which the spots may be so greatly reduced and split that they cannot be counted.

The 12 other forms of *Leptodeira* in Mexico and Central America belong to 4 other groups. The *frenata* group includes *frenata, y. yucatanensis* and *y. malleisi.* It is characterized by having head and nape marks much as in in the *punctata* group, generally 2 preoculars, and ventrals 174 to 191; the scale rows are 21(23)–17(15), the subcaudals 64 to 81, and the body rhombs 18 to 39.

The *annulata* group consists of the four subspecies of *annulata: a. annulata, a. polysticta, a. taylori* and *a. septentrionalis.* Diagnostic is the combination of distinct head and nape marks, generally 3 preoculars, and ventrals 186 to 211; the scale rows are (19)21(23)–17(15, 14), the caudals 63 to 102, the rhombs on body 23 to 66.

The *maculata* group includes only *maculata* and *smithi,* and is distinguished by the absence of dark head or nape marks (a light band around the neck is the rule), and by having 23(25)–17(15) scale rows; the preoculars are generally 2, the ventrals 166 to 181, the caudals 55 to 81, and the rhombs on body 12 to 48.

The *nigrofasciata* group includes only *mystacina* in Mexico, but elsewhere it is represented by at least two species, *nigrofasciata* and *bakeri.* Characteristic of the group is the reduction of scale rows to 19–17, and the absence or reduction of distinct dark head or nape markings; the preoculars are generally 2, the ventrals 168 to 196, the caudals 65 to 79 and the rhombs on body are very large, 10 to 24.

Lines of evolution within the genus, as represented by the 16 Mexican and Central American species, are not very clear. The accompanying diagram expresses in a general way the supposed relationships of the species and subspecies of this area. It is obvious that the *punctata, frenata* and *annulata* groups are very closely related, and that the *maculata* and *nigrofasciata* groups are not particularly closely related to each other or to the other groups. But whether the two last named groups, with their large spots, few preoculars, and no head markings are actually primitive or specialized is not certain. On the basis of geographic gradients in the several groups, it can be stated that, in general, toward the north a reduction in scale rows, a reduction in number of preoculars, a reduction in number and increase in size of blotches, a loss of head markings, and decrease in size, are the rule. These trends are clear in all groups except the *punctata* group, the most primitive of its section and perhaps of the genus, in which just the reverse occurs with respect to pattern.

No group exists in Central America or Mexico that can be considered primitive for the whole genus. *L. rhombifera,* which Dunn (1936: 690) believes the most primitive, certainly belongs to a group which appears to be in more or less an ancestral position with respect to the *frenata* and *annulata* groups, but that the group is to be considered in the same light for both the

maculata and *nigrofasciata* groups is very dubious. Of these two the former is closest to the *punctata* group, as shown by the generally similar body pattern, numerous scale rows and large size. The derivation of the *nigrofasciata* group, however, is rather clearly relatively independent of the others of the genus. The closest approach is shown by *bakeri*, a species from Aruba Island off the north coast of South America, in which the dorsal blotches may reach the number of 24 and there may be indistinct head markings. Even this does not demonstrate in which group, of any of the 4 others considered, the *nigrofasciata* group finds its closest relationship. Perhaps other South American species may furnish evidence on this point.

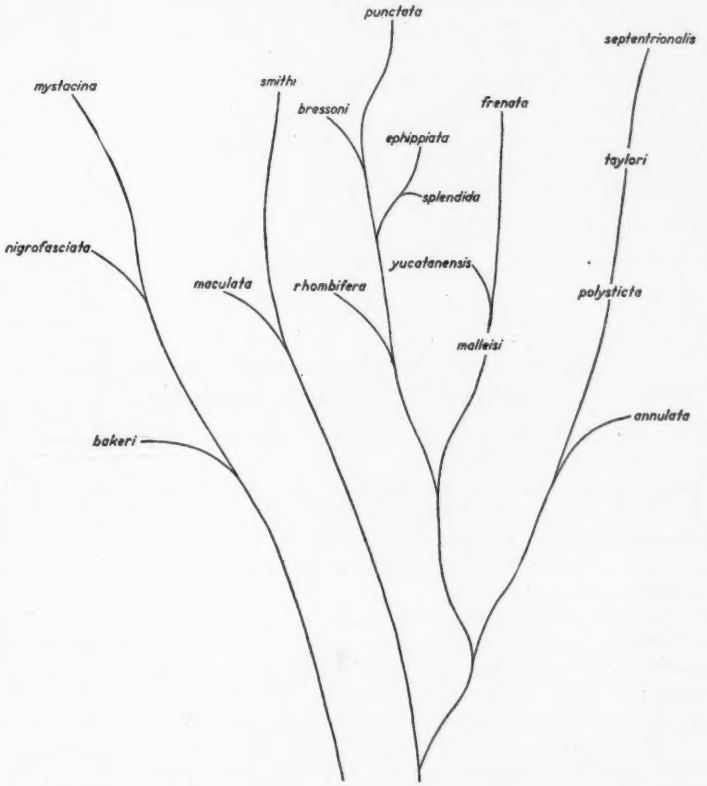

Fig. 1. Suggested phylogeny of Mexican and Central American species and subspecies of *Leptodeira*.

We are much indebted to the authorities of the Museum of Vertebrate Zoology, particularly Mr. Thomas Rodgers, for the privilege of examining and describing the type of *L. ephippiata;* to the authorities of the U. S. Na-

tional Museum, particularly Dr. Doris Cochran, for the same privilege for the paratype; and especially to Dr. E. H. Taylor who has generously loaned valuable comparative material. Needless to say the generic and regional summaries of Dunn and Taylor (*vide infra*) have been indispensable to the definition of the intrageneric groups.

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Respiration of Reptiles as Influenced by the Composition of the Inspired Air

By W. C. Randall, D. E. Stullken, and W. A. Hiestand

THE demonstration of the inhibitory effect of carbon dioxide on the respiratory activity of certain birds (Hiestand and Randall, 1941) makes evident, in view of the phylogenetic kinship of birds and reptiles, the need for a comparative investigation of the rôle played by carbon dioxide in reptilian respiration.

Benedict (1932) mentions the work of Siefert (1896) who studied the mechanics of respiration of various reptiles. Since Siefert did not include breathing rates, Benedict recorded the average breathing rates of certain snakes used in his study of the respiratory metabolism of large reptiles. The remarkable ability of turtles to survive while submerged for long periods of time is well known. Johlin and Moreland (1933) recorded survival of turtles breathing pure nitrogen for twenty-seven hours, while Lüdicke (1936) reported that one of his turtles lived under water for eight days. The latter stated that aquatic turtles respire under water by bucco-pharyngeal movements forcing water into and out of the vascular mouth. He also noted that the cloacal bladder expands simultaneously with the lungs and is concerned in underwater respiration of turtles. Wolf (1933) reported respiratory periods alternating with non-respiratory periods in the turtle. Lumsden (1923)

held that reptilian respiration is apneustic,[1] and located a definite apneustic center (1924). He believed that blood carbon dioxide is the chief factor involved in the regulation of normal respiration. Shaw and Baldwin (1935) suggest that the ability of the turtle to extend apnea over a long period of time depends upon thorough lung ventilation, low oxygen consumption, and a low "unloading tension" of turtle hemoglobin.

Parker (1925) found that the alligator can remain under water for five hours before drowning while one of the species of cayman drowns in a little less than an hour. Dill and Edwards (1931) report that the respiratory center of crocodiles seems to be tolerant toward changes brought about by carbon dioxide accumulation, but its response to lack of oxygen (anoxia) is qualitatively similar to that of the respiratory center of man. These authors show also (1931) that because of the indifference of the respiratory center to accumulating carbon dioxide and the great effect of acid on decreasing the affinity of hemoglobin for oxygen, the crocodile is well equipped to utilize all available oxygen in the lungs.

E. F. von Saalfeld (1934) observed that respiration of lizards is characterized by triphasic thoracic and abdominal movements and by complete closure of the glottis at the end of inspiration. Boeleart (1940) has recently studied the effects of anoxia and excess of carbon dioxide on the lizard *Lacerta ocellata*. He found that deficiency of oxygen caused first an augmentation of breathing followed by depression. A slight increase in volume of respiration was caused by 1% carbon dioxide but 5 to 10% caused an inhibition.

Hanson (1941) points out that the movement of air to and from the lungs in the box-turtle is essentially similar to the diaphragmatic breathing of mammals in contrast to the erroneous older opinion that turtles swallow air like amphibians. This is made possible by the contraction of two flank muscles that enlarge the coelome, thereby drawing air into the lungs. The pectoral girdle passively rotates forward during inhalation. Expiration results from the contraction of two pairs of muscles, which compresses the viscera against the lungs. This action is further aided by pulling in the neck and legs. He notes that the mechanical similarity of turtle and mammalian respiration was mentioned by Gage in 1883.

McCutcheon (1941) points out that the primary breathing mechanism in turtles is the movement of muscular diaphragms located at each leg pocket in the shell and ventral to the viscera together with the muscular closure of the glottis opening. Hyoid movements are regarded as probably olfactory rather than respiratory. Recently (1943), by ingeniously devised apparatus he has shown that the breathing cycle of turtles consists of an expiration, an inspiration, a compression, and an interval of apnea. Various adjustments of the cycle occur with changing respiratory demands. Expiration is the result of contraction of paired muscular membranes, anteriorly the diaphragmaticus and posteriorly the transverse abdominis; inspiration the result of contraction of the serratus magnus anteriorly and the oblique abdominis posteriorly.

[1] Apneusis is a term coined by Lumsden meaning "a tonic sustained contraction of the respiratory muscles."

Materials and Methods

Fourteen species of reptiles representing the four major orders of the class Reptilia were available [2] for studies of normal breathing and the effects of hypoxia, hyperoxia, and hypercapnia. The animals used include the following:

Order Testudinata (turtles)	*Terrapene carolina*
	Chrysemys picta dorsalis
	Pseudemys sp.
Serpentes (snakes)	*Drymarchon corais couperi*
	Elaphe obsoleta obsoleta
	Lampropeltis getulus getulus
	Thamnophis sirtalis sirtalis
	Thamnophis radix
Sauria (lizards)	*Gerrhonotus infernalis*
	Gerrhonotus multicarinatus
	Sceloporus undulatus
	Phrynosoma cornutum
	Heloderma suspectum
Loricata (alligators, etc.)	*Alligator mississipiensis*

Respiratory movements were recorded by the use of appropriately constructed "plethysmographs" designed to accommodate the particular reptile, as described below. An exception was made of the alligator, whose respiratory movements were recorded by means of an accordion type pneumatograph. Because of the external similarity in structure and breathing movements of the alligator to mammals this method of recording proved successful. Peculiarities of external structure of reptiles in general made the recording of respiratory movements essentially a different problem with each different species. Much of the difficulty can be eliminated if the animal is placed in a rigid plethysmograph, which in turn communicates with a recording tambour. Displacement of air in the plethysmograph then becomes quantitative, within limits, and the respiratory movements are essentially unhampered.

The snakes were placed individually in glass tubes with the animal's head extending from one end of the tube. The head was fastened outside with a rubber cuff placed around the neck. The opposite end of the tube received a stopper pierced by a glass tube which was attached to the recording tambour. To prevent optical stimulation the eyes of the snakes were taped. Because it became apparent that snakes are exceptionally sensitive to auditory stimuli all records were taken at night when the laboratory was quiet.

Due to their body form the lizards were encased in containers of varying shapes and sizes with the head outside the container. An air tight seal was made around the neck of the animal with plasticene. The eyes and auditory meatuses were also closed with plasticene.

The turtles were placed in a coffee tin with a hole in the side through which the head of the animal was pushed and sealed with plasticene. An outlet tube connected with a recording tambour. It might be mentioned that

[2] The authors wish to acknowledge the liberal support of Mr. W. B. Hopp in permitting the use of animals taken from his private collection.

the only sign of external movement in the breathing turtle is the movement of the loose skin between the shell and the legs. That this is proportional to the displacement of the lungs inside of the body is obvious.

Gases of different composition were applied by way of special hoods designed to fit loosely over the reptiles' heads. With the hood in place different gases could be administered without disturbing its position. Gases were mixed in a specially designed gasometer, the outflow rate of which was regulated by a water trap. By this method any desired gas or mixture of gases could be passed over the head of the animal, making it impossible for it to inspire anything else. The gaseous composition of the air stream inside the hood was checked by a Haldane apparatus. All experiments were carried out at temperatures between 20 and 25° C.

In the figures of normal respiration, in each case, the first part is made with the slow drum with one minute time intervals and the second part is with fast drum, with one second intervals, except for the alligator, for which the fast drum interval is five seconds. In the kymograms of respiration as affected by carbon dioxide, the space between the dashes represents the duration of the time of application of 10% carbon dioxide in air, and the intervals are one minute in all. In Figures 1 to 3 the upstroke represents inspiration; in Figure 4, the upstroke represents expiration.

Respiration of Turtles

The normal respiration of the painted turtle (*Chrysemys picta dorsalis*), an amphibious form, includes rather irregular series of short respiratory cycles followed by a prolonged period of apnea. Apnea is always terminated by an active expiration that requires slightly more than one second for completion. This expiration is held for a brief instant and then the lung volume is nearly doubled by a very rapid inspiration. This is followed by a slow return to the normal state of maintained partial inspiration. Several such complete respiratory cycles may occur in rapid succession followed by prolonged apnea. One cycle is completed in about 3.5 seconds, with approximately 70% of the time spent in expiration. Some turtles show a somewhat different respiratory cycle in that the first inspiration does not fill the lungs above the normal maintained state of inspiration.

Effect of carbon dioxide.—The effect of 3% carbon dioxide was almost imperceptible but both 5 and 7 % produced long periods of apnea (8 minutes with 7%) followed by an increase of both rate and amplitude. Higher concentrations (10, 15 and 20%) caused a progressive decrease in duration of the apnea and a progressive increase in stimulation. With these higher concentrations a deep expiration was followed by a greatly exaggerated inspiration with very little pause between successive cycles. Stimulation largely outweighed the inhibition with administration of 20% carbon dioxide, that is, the initial apnea was reduced to a little more than one minute's duration, and stimulation continued as long as the carbon dioxide was breathed. Removal of the carbon dioxide resulted in a rapid return to normal.

Effect of hypoxia.—Administration of pure nitrogen produced no immediate effects on the respiration of the turtles used. In fact, when one turtle

was allowed to breath pure nitrogen for sixty minutes no marked stimulation occurred at any time. In most experiments however, increase of amplitude was noted after approximately eight to ten minutes of nitrogen application, and this may or may not be accompanied by an increase in rate. Mixtures containing 5% oxygen in nitrogen were somewhat slower in bringing about a stimulation, while mixtures of 10% oxygen often failed to produce any stimulation. Turtles are therefore capable of withstanding severe hypoxia or even anoxia for long periods of time, and apparently only slight traces of oxygen are necessary to maintain life for long periods.

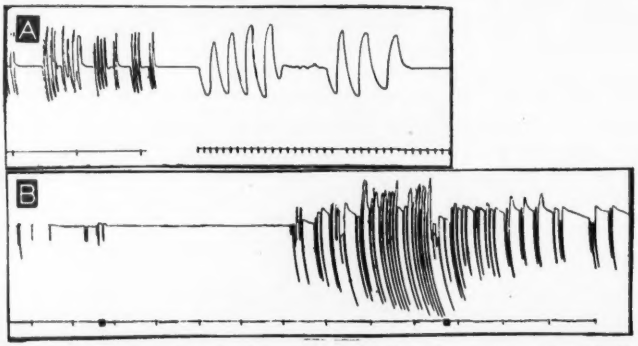

Fig. 1. Kymograms of respiration of the painted turtle. A. Normal respiration. B. Effect of 10% carbon dioxide.

Respiration of Snakes

Normal respiration of the Florida indigo snake (*Drymarchon corais couperi*) consists, as in the turtle, of a succession of respiratory cycles followed by apnea. The apnea is not as pronounced as that in turtles, and the total time required for the completion of the cycle is considerably longer (about fifteen seconds). Of this time, about 85% is spent in expiration. Each respiratory cycle consists of an initial active expiration often in the form of a series of short exhalations until the lungs are partially or completely emptied. A rapid and forceful inspiration then fills the lungs to about twice their original volume and then gives way to a slow passive expiration until the lungs reach their normal state of expansion held during apnea. It appears that with each cycle the lungs are ventilated by first blowing off the accumulated carbon dioxide, inflated to about twice their original volume, and then gradually return to normal. Respiration is regular and not marked by irregular periods of apnea, the normal rate being slightly more than one cycle per minute, this varying somewhat with the state of activity and temperature of the snake. Smaller snakes usually have faster breathing rates.

Effects of carbon dioxide.—With administration of concentrations of carbon dioxide from 2.5% to 10% in air the first expiration was not affected but the inspiratory phase was greatly shortened. Instead of the usual six seconds necessary for return to normal lung volume, the inspiration was cut short and returned in less than one second. The succeeding expiration was

then shortened while the rate of breathing increased. The first inspiration of air after removal of carbon dioxide was followed by the delayed, passive return to normal, and breathing immediately assumed the characteristics of normal respiration. With increasing concentrations of carbon dioxide these effects became more pronounced until 15 and 20% concentrations were reached. With these concentrations, an initial period of apnea was often noted followed by increased amplitude, which may be terminated by severe struggle. Prolonged administrations of lower concentrations often had the same end result. The prominent effect of hypercapnia (excessive carbon dioxide) in the snake is a decreased amplitude or volume of breathing with a marked increase in rate.

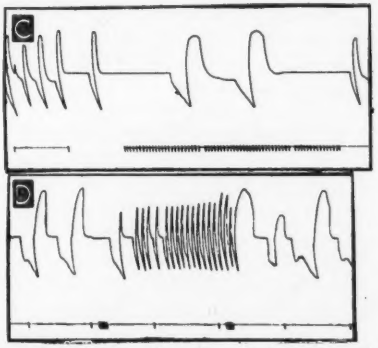

Fig. 2. Kymograms of respiration of snakes. C. Normal respiration in the Florida indigo snake. D. Effect of 10% carbon dioxide on respiration of the pilot black snake.

Effects of hypoxia.—Administration of pure nitrogen was marked by an increased volume of expiration and inspiration noticeable after about three minutes. The initial effect is one of increased amplitude followed by increased rate. The great stimulation thus produced lasts for some time after the snake is allowed to breathe air. The same tendency was shown by 5–10% oxygen after longer periods of administration, but 15% oxygen produced very little definite effect. The requirement for oxygen then seems to lie somewhere between 10% and 15%. The effects of hypoxia were always gradual in appearing and disappearing. Cessation of hypoxia was sometimes followed by rapid breathing (polypnea). The prominent effect was one of increased amplitude followed by an increase in rate.

Respiration of Lizards

The normal respiratory cycle of the alligator lizard (*Gerrhonotus infernalis*) closely resembles that of the turtle and snake, that is, the expiration is the most prominent phase of the complete cycle and is first noted as an interruption of apnea. A sharp and rapid inspiration inflates the lungs only slightly above the normal resting state of maintained inspiration. The entire cycle is completed in about six to ten seconds with 80% to 90% of the cycle spent during expiration. Apneusis is more prominent in this group than in other reptiles.

Effect of carbon dioxide.—Administration of low percentages of carbon dioxide (3%) in air produced a prompt reduction of breathing rate with but slight effect on amplitude. Greater inhibition was produced by 7% and 10% mixtures where both rate and amplitude were initially inhibited. After a few minutes of apnea, however, stimulation broke through the inhibition and breathing gradually became active. The same tendency was produced by 20% carbon dioxide, but here again the stimulation proved stronger than the inhibition and apnea was terminated by strong expiration and inspiration. It therefore appears that low concentrations of carbon dioxide may stimulate inhibitory receptors in the respiratory passages but higher concentrations produced stimulation possibly by way of central mechanisms.

Some specific differences were noted with *Gerrhonotus multicarinatus* which showed immediate stimulation in amplitude and rate with administration of carbon dioxide in all concentrations from 3% to 20%.

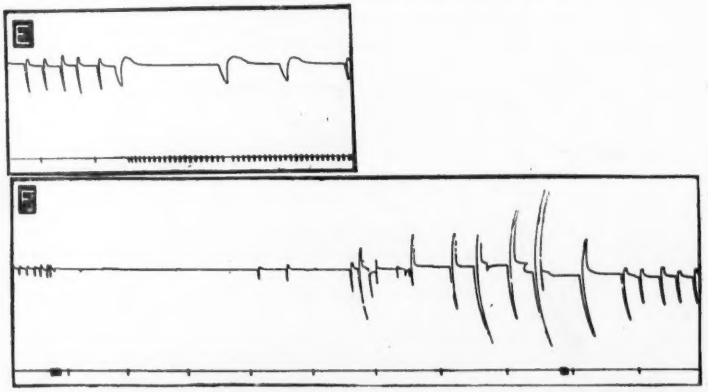

Fig. 3. Kymograms of respiration of the Texas plated lizard. E. Normal respiration. F. Effect of 10% carbon dioxide.

Effects of hypoxia.—Breathing pure nitrogen produced augmentation of amplitude after four to five minutes. The same stimulation was produced by 5% oxygen in nitrogen after a longer administration. Mixtures of 10% and 15% oxygen produced some stimulation after slightly longer periods. In all experiments, the chief effect of hypoxia was one of increased amplitude of breathing rather than rate, and the stimulation always developed gradually.

Respiration of the Alligators

Normal respiration of the alligator (*Alligator mississipiensis*) consists of an active expiration followed by four to eight cycles of expiration and inspiration until the glottis is closed at the peak of a final inspiration. Air then gradually leaks out of the glottis until the lungs reach a normal state of expansion held during an indefinite period of apnea or until another series of cycles is initiated by a forceful expiration. The initial active expiration lasts from 3 to 4 seconds, the intermediate inspirations last from 2.5 to 3.5 seconds and the passive expiratory phase may last from 8 to 20 seconds.

Effects of carbon dioxide.—2.5% carbon dioxide had little effect on respiration for three minutes after which the amplitude of breathing was increased almost 50%. There was often a decrease in number of cycles in a given series of respirations and a shortening of apneic periods. All percentages of carbon dioxide through 20% had essentially the same effect. Rate and volume of breathing was roughly proportional to the percentage of carbon dioxide administered. With the higher percentages, the effect was more prompt in appearing and the period of recovery was more delayed.

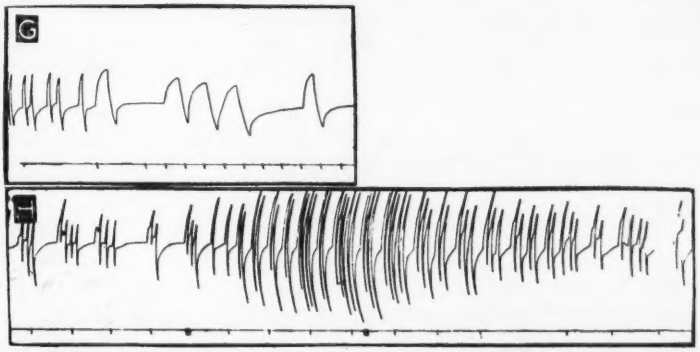

Fig. 4. Kymograms of respiration of the common alligator. G. Normal respiration. H. Effect of 10% carbon dioxide.

Effect of hypoxia.—Pure nitrogen caused progressive stimulation of amplitude and volume. The rate was increased and the cycles in a given series decreased to one. The final passive expiration was shortened and the rate became very regular. When the gas was replaced by air, the volume became still greater but soon assumed the characteristics of normal periodic respiration. Volume returned to normal in five minutes. 5%, 10% and 15% oxygen mixtures were administered with gradually decreasing stimulation with higher oxygen percentages. The general effect of hypoxia was increased amplitude of breathing movements in order to replenish the oxygen supply in the lungs.

Hyperoxia.—Administration of 100% oxygen for prolonged periods showed the same general inhibitory tendency in all reptiles, that is, there was a slight decrease in amplitude of breathing and in some a decrease in rate.

Conclusions

The normal respiration of all the reptiles used in this study is apneustic in nature and consists of an active expiration followed by one or more inspirations and a final slow passive expiration as the lungs return to a normal state of maintained partial distention (apneusis).

In the turtle carbon dioxide produces an initial apnea which is followed by increase of both rate and amplitude of breathing. Severe hypoxia produces an initial increase of amplitude with some increase of rate, although slight traces of oxygen appear sufficient to maintain life for long periods.

In the snake carbon dioxide produces decreased amplitude with a promi-

nent increase in rate of breathing. Hypoxia produces a progressive increase of amplitude followed by an acceleration in rate.

In lizards prompt inhibition of breathing generally results from administration of low percentages of carbon dioxide. High concentration of carbon dioxide generally produces definite stimulation. Augmentation of amplitude follows low oxygen administration.

In the alligator carbon dioxide produces definite augmentation of both rate and amplitude, the rate of breathing and volume of air breathed being approximately proportional to the percentage of carbon dioxide inhaled. Nitrogen causes an immediate and progressive increase in amplitude.

Hyperoxia in all reptiles used causes a slight decrease in amplitude and rate of breathing, indicating apparently a continual hypoxic respiratory drive.

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Food of the Red-backed Salamander

By E. W. Jameson, Jr.

THE following account reports the stomach examination of 169 red-backed salamanders (*Plethodon cinereus* Green) collected near Ithaca, New York, from October 2 until November 10, 1942. One hundred and forty-nine contained food while 20 were empty or nearly so. The collections were made at several stations, the majority of specimens being taken in mixed hardwood and pine-hemlock woodlands. Most of these were found under rotting logs and flat rocks. A large number were found under flat stones in dried up stream beds; perhaps the damper soil presents an easier path to the hibernating quarters, wherever this may be. The individuals were solitary, or were sometimes found in groups of 3 or 4. On November 10, one salamander was found, and none were seen thereafter.

The salamanders were put immediately into 10% formalin, and examined later in the laboratory. At the same time, the writer made a collection of invertebrates from the habitat of the salamanders in hope that it would assist in the future determination of food items. Once identified, these items were compared with those taken from the salamanders' stomachs.[1]

The percentage by bulk of the food elements in each stomach was estimated as carefully as possible, and the results are analyzed in the Table. This paper will serve as a supplement to those of Surface (1913), Blanchard (1928), Smallwood (1928), and Hamilton (1932).

Insects made up 73.2% of the total, and occurred in almost every stomach. The order Coleoptera was most important, both adults and larvae forming over 20% of the total stomach contents. Carabids, chrysomelids, staphylinids (*Philonthus* and *Staphylinus*), curculionids, and lampyrids were frequently encountered. Elaterids (*Melanotus*), alleculids, and cryptophagids were found sparingly. Diptera formed 10.5% of the total, and sometimes constituted the entire stomach contents of an individual. Tipulid larvae commonly occurred under rotting logs, and sometimes 6 or 8 form the last meal of a salamander. The larvae of a species of *Bibio* were often found under stones in large aggregations, and were much eaten by the salamanders. Hymenopterous remains formed slightly less than 10%, about half of which were ants (*Lasius* sp. and others). Hibernating wasps were frequently found under the same logs as were the salamanders, and the smaller species were sometimes eaten. Lygaeids and tingids (lacebugs) were the most common hemipterans, and the order made up 5.6% of the total. A number of lepidopterous larvae were eaten. Many of the leaf mining larvae listed as unidentified insects are undoubtedly of this order. One might well speculate as to how the salamanders obtained such food; sometimes bits of leaf remained with the insect, making certain their origin. Several red-backs had dined upon the wingless females of moths distended with brown, keg-shaped eggs; and not infrequently the eggs alone served to identify this insect. Thrips

1 For the identification of this latter collection, I wish to thank the following gentlemen: Dr. Henry Dietrich, Coleoptera; Dr. J. C. Bradley, Formicidae; Dr. O. A. Johannsen, Diptera; and Mr. W. S. Newcomer, Gastropoda. To Dr. A. H. Wright, who assisted with the text, I tender my thanks.

were found in only two stomachs, but occurred in these to the exclusion of almost everything else.

The most important single item was earthworms, which formed 6.7% of the total and was often the only food in a stomach. Sowbugs (mostly *Aniscus asellus*) and small snails were frequent, each being found in 15% of the stomachs examined. Small slugs (*Deroceras agrestre*) were also eaten. Spiders seemed to be sought after, but were always too well digested to be identified. Mites were a small part of many meals. A small acarinid cocoon attached to a hemlock needle was commonly found. Hamilton (*op. cit.*) mentions this item as present in many stomachs.

This study indicated that three-fourths of the fall food of the red-backed salamander (*Plethodon cinereus* Green) is insects, both adults and larvae of several orders being well represented. Earthworms, snails, slugs, and spiders are the most important non-insect foods.

A Stomach Analysis of 169 Red-backed Salamanders, *Plethodon cinereus* Green, from Ithaca, New York

Food item	No. of stomachs containing item	Percentage of stomachs containing item	Total no. of item in all stomachs	Percentage by volume
Total insects	..	....	..	73.2
Coleoptera	78	53.2	98	20.6
Carabidae	12	8.6	15	3.4
Staphylinidae	8	5.7	8	1.0
Curculionidae	5	3.6	5	1.0
Crysomelidae	4	2.8	4	1.5
Cerambicidae	1	0.7	1	0.7
Elateridae	1	0.7	1	0.9
Lampyridae	4	2.8	4	1.1
Misc. Coleoptera	43	30.7	60	11.0
Hemiptera	24	16.1	55	5.6
Tingidae	13	9.3	42	3.0
Lygaeidae	3	1.1	4	1.1
Misc. Hemiptera	8	5.7	9	1.5
Diptera	43	31.7	74	10.5
Hymenoptera	36	25.7	49	9.0
Formicidae	12	8.6	20	4.0
Misc. Hymenoptera	24	17.1	29	5.0
Lepidoptera	12	8.6	24	4.7
Thysanoptera	2	1.4	570	0.7
Unidentified insects	64	47.5	95	22.1
Total non-insects	..	....	..	26.8
Earthworms	16	11.4	17	6.7
Snails	20	14.3	31	2.9
Slugs	5	3.6	7	2.5
Spiders	13	9.3	16	6.5
Mites	15	10.7	20	0.8
Centipedes	8	5.7	9	2.4
Millepedes	6	4.3	9	1.1
Unidentified	..	....	..	3.9

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Notes on the Breeding of *Hyla nigripes* in Costa Rica

By MIRIAM STOKES JAMES

AMONG the frogs of northern Costa Rica *Hyla nigripes* is distinctive in being the only form known to breed during the dry season (with the exception of *Bufo marinus*). Breeding occurs in the many small streams, which gradually dry up after the heavy rains of the wet season, leaving small pools and areas of quiet water along their edges. Two such streams were available for daily observation during my stay near the little settlement of La Sierra, in Guanacaste, the northwestern province of Costa Rica. Many others were visited for collections and observation over an area of about 3 square miles.

Hylas were first heard early in the evening of October 19, after a clear day near the end of the rainy season. Collections made in two brooks on that date revealed only males. They were heard again on October 23, a clear night after three days of rain, and two females were collected, together with several calling males. The call is somewhat like that of *Hyla crucifer*, but lower in pitch, and is intermittent, repeated one to four times with long intervals between the periods of calling. The males appear to call in unison, so that after a period of silence all the frogs in one region of the brook will call together, with those in nearby streams occasionally joining. Calling sites are almost always rocks in the center of the stream, although individuals were seen calling from small patches of sand and in rare instances from low vegetation on the banks of the stream. Like most species of *Hyla*, they will continue to call in the direct beam of a flashlight. The chorus regularly began just before sundown and strangely enough was never heard after a late afternoon rain, even when the evening was clear, although a shower late in the evening did not affect it, once the calling had begun. It continued intermittently until December 27, due no doubt to the unusually late onset of the dry season, but after that date calling was heard every night and the species was abundant in the streams.

On several occasions tree frogs were found at some distance from the brooks during the day, on shaded leaves of bushes or in cool, damp areas below houses. All such individuals were females. Males were found only in the brooks or low on their banks, while females were caught higher on the banks, in low bushes along the edge, and often at a considerable distance. Whether this is significant or represents only chance collection is not certain, although the large number of individuals taken appears to support it.

Copulating pairs were not found at any time, although males were often seen "stalking" females. The first clutch of eggs was found on December 12, though newly-emerged larvae had been seen on December 7. The eggs are laid in small, quiet pools of water formed between rocks along the edge of the brook as the water level is lowered. They were also found in water-filled hoofprints along the sandy edges of a pasture brook and in small areas of water left in depressions by the drying of the streams. Eggs are laid singly or in loose, irregular masses on the bottoms of the little pools, sometimes attached to fragments of dead leaves or twigs. The masses contain from 20 to 50 eggs, and are much like those of *Hyla regilla* in appearance, though still less compact.

Upon emerging, the larvae are a slaty gray. By the time the tail fin is well formed and the operculum is developed the color has changed to a dark brown, flecked with yellow. Older tadpoles often bear a yellow mid-dorsal line, especially prominent along the tail. Just before the emergence of the hind limbs there appear large red-brown chromatophores along the length of the tail. The younger tadpoles cling to pebbles or sand grains on the bottom of the pool, while older ones have been found venturing into the swifter waters near the center of the streams. Since the lowering of the water-level in the brooks occurs rather rapidly, draining many of the little pools dry in a few days, the mortality among tadpoles must be very high. It is significant that only *Hyla nigripes* and *Bufo marinus,* both forms with a relatively short larval life, breed under such conditions in Guanacaste.

By the first of February both calling adults and tadpoles showed a sharp decrease in numbers. The pools along the edges of the brooks and the quiet areas of water where the streams widened were now occupied by large numbers of the shiny black tadpoles of *Bufo marinus,* and only a few large *Hyla* tadpoles were encountered. New clutches of eggs were occasionally found through March and into April, when the last, a small egg-mass with newly-emerged larvae, was seen (April 6). By early April calling had almost ceased, and only one or two frogs were found in any of the streams visited; by April 15 not a single individual was heard or seen. One female was brought in from some distance on April 12.

A short larval stage in *Hyla nigripes,* a still-water breeder like most of the Hylidae, makes possible egg-laying, development and metamorphosis in the dry season in small temporary pools, which during the rainy season would be washed by a swift current.

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Sexual Maturity in the Female of the Turtle *Pseudemys scripta elegans* [1]

By Fred R. Cagle

SOME data on the slider turtle (*Pseudemys scripta elegans* Wied), obtained in Illinois, provide information on the age and size at sexual maturity, the annual reproductive cycle, and on the character of the eggs.

Since the female slider turtle does not develop any conspicuous secondary sex characters, maturity in this sex can be determined only through field observation of nesting individuals or by the examination of the reproductive organs. The latter method has been most useful. The technique of detecting the presence of oviducal eggs (Cagle, 1944) has furnished some data and the examination of ovaries the remainder. The ovaries were removed, hardened in formalin, and retained in alcohol. The total volume and weight of each pair of ovaries and the greatest diameter of all follicles larger than 3 mm. were recorded.

Of the 817 females in the size range 120–260 mm. (plastron length) examined, 52 specimens in the smaller groups, 120–160 mm., contained no oviducal eggs. Thirty, ranging in size from 164 to 260 mm., contained oviducal eggs, and were part of a total of 114 examined during May, June, and July (Table I). The data from these delimit the egg-laying season and suggest the minimum plastral length of females when they deposit their first eggs.

TABLE I

THE OCCURRENCE OF EGGS IN THE OVIDUCTS OF FEMALES DURING MAY, JUNE, AND JULY

Size range (mm.)	No. examined	Specimens with oviducal eggs
120–160	52	0
160–170	5	1
170–180	6	4
180–190	13	8
190–200	10	3
200–210	13	5
210–220	8	2
220–230	4	4
230–240	2	2
240–250	0	0
250–260	1	0

The ovaries provide a second source of information on the attainment of sexual maturity. Each of the 30 females containing oviducal eggs also had several ovarian follicles with an average volume only slightly less than the average volume of the yolks of the oviducal eggs. Follicles of similar size were also present in females examined during August, September, October, March, and April. Since the season of activity for these turtles in southern Illinois extends from early May to early October, these data suggest that the only seasonal change in the gross appearance of the ovary is a gradual increase in the size of the follicles, which, in mature individuals, advances one set to the ovulatory stage each season.

[1] Contribution from the Museum of Natural and Social Sciences, Southern Illinois Normal University.

All of the females examined with the largest follicle 10 mm. or more in diameter had 2 or more groups of follicles. Agassiz (1857) first noted that the turtle ovary contained eggs of different sizes falling into 2 or more groups. He compared the number of follicles in each group with the average number of eggs laid by turtles of the species concerned and concluded that each group of ovarian follicles represented a clutch of eggs. Thus it is possible to formulate a procedure adequate for determining the probable fecundity of an individual for 2–4 future seasons, which will contribute much to the advance of our knowledge of turtle populations.

As the sexual maturity of females containing oviducal eggs is unquestionable, and, as such females have follicles only slightly less in size (15–23 mm. in diameter) than the yolks of oviducal eggs, it appears that any female containing follicles greater than 15 mm. in diameter is potentially capable of depositing a clutch of eggs in its next season of activity. The data available suggest that turtles with the follicles much less than 15 mm. in diameter will not deposit eggs for two seasons. Any female having follicles 15 mm. or greater in diameter is here considered mature.

Of 183 females in the size range 70 to 260 mm., examined by dissection, 45, with lengths of 160 to 260 mm., had the largest follicle 15 mm. or more in diameter, and 138 with lengths of 70 to 230 mm. had the largest one less than 15 mm. in diameter. Of the latter, 7 (210–220 mm.) had senile ovaries. It is evident that some turtles do not attain sexual maturity until they have a plastron length of 230 mm. while others may become mature at a length of 160 mm. Of one group of 37 females collected from a drainage ditch near Murphysboro, Illinois, on March 31, 1941, 12 (120 to 170 mm. in length) had ovaries weighing less than .5 gram; the remaining 25 had heavier ovaries. Only 3 turtles with a plastron length greater than 60 mm. had ovaries weighing less than 5 grams. As the largest follicles had a diameter of only 3 mm., the turtles were undoubtedly immature. Seven of the individuals larger than 160 mm. had ovaries weighing 5–10 grams, but in all of these the largest follicles were 5 mm. or more in diameter. One of these 7, with a plastron length of 220 mm., was an old female, as evidenced not only by the thickness of the plastron and carapace and the obscured color pattern but also by the ovaries, which were thin and contained comparatively few follicles. In the complete ditch sample no turtles with a plastron length less than 170 mm. contained follicles larger than 3 mm.; and in only 2 of the larger turtles was the maximum follicle size as small as 3 mm.

It has been commonly assumed that fishes and reptiles remain reproductively active throughout their lives. The repeated observation of senile turtles has indicated that this is not true for the species considered here. Of 183 females examined, 7, ranging in size from 210 to 220 mm. and apparently of great age, contained senile ovaries.

Twenty-eight female turtles collected in southern Illinois had from 5 to 13 eggs, mean 9.4. One turtle collected at Lake Springfield, in central Illinois, contained 20 eggs. Cahn (1937: 168) states that the number of eggs varies considerably, depending upon the size and age of the turtle, large complements containing 20 and even 23 eggs. He finds the average number of eggs to be between 15 and 18, and regards small clutches of 6 to 8 eggs as representing the first efforts of a young female. In my own report of 47

nests (Cagle, 1937: 88) the average number of eggs was 10.5, the range 5–22.

There is a significant correlation (r = .70) of the number of eggs with plastron length. The largest female contained 20 eggs, the smallest 10. If we assume that plastron length of mature females is closely correlated with age, as Cahn apparently did, these data verify his statement that the small egg clutches are those of young females.

That much variation in clutches of turtle eggs may occur is suggested by Hildebrand, who points out (1929: 68) that the egg production of the diamond-back terrapin fluctuated greatly from year to year within lots and within broods, and that the number of eggs produced by individuals of the same age varied from 5 to 29 during a single season.

Some turtles are known to produce more than one egg clutch in one season. Hildebrand (1929: 65) states that the diamond-back terrapin may lay only once during a season, or she may lay as many as 4 and rarely, 5 times. Mitsukuri (1895: 144) reports a large soft shell (*Trionyx japonicus*) that laid 4 groups of eggs in 1894 between the dates June 1 and July 23 and 3 groups of eggs in 1895 between the dates June 14 and July. He states that the difference in number of broods per season is due to meteorological condition, condition of ponds, supply of food, and age of individuals. The green turtle (*Chelonia mydas*) has been reported by Moorhouse (1933) to lay as many as 7 clutches at intervals of approximately 2 weeks. Since a set of ovarian eggs only slightly smaller than the yolk of oviducal eggs is present in the ovaries of *Pseudemys* in the breeding season, it may be supposed that under favorable conditions a second clutch might be deposited.

The 221 eggs measured range from 30.9 to 43.0 mm. in length, mean 36.2 mm.; 19.4 to 24.8 mm. in width, mean 21.6 mm.; and from 6.1 to 15.4 grams in weight, mean 9.71. There is no significant correlation of size of eggs or largest follicle with the size of the turtle.. Cahn (1937: 168) reports that 121 eggs of this species averaged 37 x 22 mm., varying from 34 x 21 mm. to 38.5 x 23.5 mm.

Of the 263 eggs collected, 125 were removed from the left oviduct and 138 from the right. There was no significant difference in the sizes of the eggs in the left and right oviducts.

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Fishes that Swim Heads to Tails in Single File

By E. W. GUDGER

THAT the higher animals follow their leaders heads to tails, all who are country bred know from having seen sheep jumping over a fence or a fallen tree. But that the hindermost of any animals, other than elephants in a parade, lays hold of the tail of the preceding animal and so forms a living chain, short or long, may be a new thing. Yet in Junior Natural History there was recently published a charming picture of a baby polar bear which, tired of swimming, had with its mouth laid hold of its mother's stubby tail and was thus getting a tow through the icy water. Other like instances might be noted, but they will make another story—for another time and another hand.

That fishes form living chains will strike the reader as something out of the ordinary, but it is true. Furthermore the earliest account goes far back in antiquity, the head-tail habit in fishes being mentioned by three ancient writers.

The first of these is Ovid (43 B.C.–17 A.D.) who writes of this habit in the *Scarus*, of which the classical writers alleged that it never deserts its fellow fish. The account is found in his "Halieuticon," lines 9–17. The Latin is very difficult and the matter not clear even in Bostock and Riley's translation in their version of Pliny's *Natural History* (Vol. II, Bk. IX, chap. 29, footnote to *Scarus*). It reads thus:

> The Scarus is caught by stratagem beneath the waves, and . . . dreads the bait fraught with treachery. It dares not strike the osiers [of which the trap is made] with an effort of its head, but, turning away, it loosens the twigs with frequent blows of its tail, and escapes safely into the deep. Moreover, if by chance any kindly Scarus, swimming behind, sees it struggling within the osiers, he [the struggler?] takes hold of its tail in its mouth, as it turns away, and so it makes its escape [being dragged through the mesh of twigs].

This account is also found in the *De Natura Animalium* of Aelian (fl. *c.* 120 A. D.), and, although the verbiage is somewhat different, the allegations

seem to be the same. The story is likewise repeated in that greatest work of antiquity on fishing, the *Halieuticon* of Oppian (fl. *c.* 172–210 A. D.). Of this there is a (somewhat florid) English translation by Diaper and Jones, fellows of Balliol College, Oxford University (Oxford, 1722). Here follows their version of this account in Book IV, lines 65–82, which makes the matter much clearer:

> Oft through the Weel's[1] inverted spiky Door,
> Their captive Friend to Freedom they restore.
> The poor imprison's Fish with shudd'ring Fright
> Perceives the Fraud, and meditates his Flight.
> Cautious with retrograde Career he slides,
> His Tail advances, and the Twigs divides.
> In vain his nuzzling Head the Passage tries,
> The dreadful Points oppose, and wound his Eyes.
> Around the Weel th' obsequious Scaros wait,
> Pensive, and studious to release their Mate.
> Down through the circling Twigs their Tails extend,
> And court the gen'rous Pain that saves their Friend.
> He in his Teeth receives the grateful Reins,
> The Straights repasses, and the Sea regains.

The next citation of this habit comes in time and place a long way from Oppian but not so far from us today. It is from *The Natural History of Norway* by Bishop Erich Pontoppidan of Bergen (English version, London, 1755). On p. 153 of Part II, he says of the *Storje* or Sturgeon, which he says grows to 10 or 12 feet in length, that: "They do not swim together in shoals, or extend in breadth, but follow one another in a straight line, laying hold of each other's tails. When a whole string of them is seen together, they are sometimes taken for a great Sea-snake."

It must have been a wonderful sight to see these great 10-foot sturgeons forming an animated chain. Pontoppidan does not say that he had seen this swimming, and it is probable that the account originated in seeing one fish swimming behind another—without the hindermost laying hold of the one in front. This laying hold would be difficult for sturgeons with their toothless jaws and more or less round mouths.

The next reference to this kind of behavior is found in C. F. Holder's *Stories of Animal Life* (New York, 1899). On p. 69 he describes the habit of certain marine gars at Tortugas, Florida, of leaping over a floating straw: "Over it in a daring leap the leader goes, followed by the rest, until the leapers in a continuous glistening stream dart into the air."

In a later book (The Log of a Sea Angler, Boston, 1906: 58–60), Holder thus describes the tandem swimming of the giant ray, *Manta birostris*, witnessed in the channels between the Keys of the Tortugas:

> . . . we saw a half dozen [Mantas] on the surface, which appeared to be swimming in a circle. . . . the rays had moved down the beach a way and were still swimming one behind the other at intervals of 10 or 20 feet. . . . Again I saw the devil fish . . . fall into line in this strange swinging around the circle.

This, together with other interesting items on the behavior of the mantas, is expanded in a chapter on "Trailing the Sea Bat" (Big Game at Sea, N. Y.,

[1] An hourglass-shaped wickerwork fish trap with the entrance end open.

1908: 1–34, 4 figs.). Holder in both books calls this behavior a "game" and surely it seemed to be. He states (p. 8) that—"There were, perhaps, ten or twelve in all, moving in a circle one hundred and fifty feet in diameter, and churning the water into a veritable maelstrom." As these great rays (12–18 feet across the wings) swung around, on edge so to speak—"They resembled enormous bats, and in following one another around the circle, raised the outer tip of the long wing-like fin high out of the water in a graceful curve, the other being deeply submerged." What a wonderful sight this procession must have been!

Holder states (p. 22) that his father, Dr. J. B. Holder (curator of zoology in the American Museum, 1881–1888), also witnessed this swimming in a circle, and other interesting behaviors, at Tampa, Florida. But nowhere have there been such opportunities for observation as in the clear waters at Tortugas, where they were easily visible at a depth of 25 feet. To my keen regret such observations were denied me while there at the laboratory of the Carnegie Institution of Washington during the seasons of 1912–15.

Louis Monaco of the American Museum states that he has often seen fishes leaping in single file in Great South Bay on the Atlantic side of Long Island. When the fisherman's line lies slack at or on the surface of the water, silversides will leap over it. "So many follow in rapid succession at times that it seems to be a game of 'follow the leader.' "[2]

Last of all to be quoted is William Beebe, who thus describes in his *Book of Bays* (New York, 1942: 92) what he saw along shore near Acapulco, southwest coast of Mexico: "I thought I saw an eel of amazing length, but before it passed from view I resolved it into a long line of unknown fish, swimming head to tail."

Why fishes swim heads to tails in single file is a question that cannot be answered here and now. One can only surmize that it is a kind of game played by the fishes. It may be doubted whether the fish behind lays hold of the tail of the one in front, but that they sometimes swim or leap in single file, heads to tails, forming living chains, is definitely established.

Fishes do many unusual and extraordinary things—as those know who have devoted years to a study of their habits. But the fish bibliographer, who reviews large amounts of the literature, learns of many more, since in the literature are preserved the accumulated observations of the past. However, on any subject there are numbers of observations that have never been transferred to the printed page. Hence, in the matter of this curious head-to-tail habit of locomotion in fishes, all the known accounts are here brought together from various obscure sources not known or not accessible to the average reader. This is done not merely because they are exceedingly interesting but also in the hope that this article may lead to the publication of like accounts by other observers, and above all of photographs of the fishes in action. In this way these incidents would become confirmed as a phenomenon, and eventually an explanation would be worked out.

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[2] The leaping habit told of by these two observers will with other like accounts be set forth in another article.

A New Loricariid Catfish from the Rio Truando, Colombia [1]

By LEONARD P. SCHULTZ

IN February, 1944, (Proc. U. S. Nat. Mus., 94: 334–335, pl. 14), I described the only known specimen of *Spatuloricaria phelpsi* as a new genus and new species from the Río Socuy, Maracaibo Basin, Venezuela.

While rearranging some jars of fishes in the National collections, I noticed a specimen that greatly resembled *S. phelpsi.* This specimen was collected by Lt. N. Michler and A. Schott during 1857 and 1858 in the Río Truando, a tributary of the Río Atrato, Colombia, and it is now described as the second species in the genus *Spatuloricaria.*

Spatuloricaria ***atratoensis,*** [2] new species

HOLOTYPE.—USNM No. 93810, a specimen 338 mm. in standard length, from the Río Truando, tributary of Río Atrato, Colombia, collected by Lt. N. Michler and A. Schott, 1857-1858.

DESCRIPTION.—Detailed measurements were made on the type and these are recorded in the table in hundredths of the standard length.

The following counts were made: Dorsal rays 1, 7; anal rays 1, 5; pectoral I, 6–I, 6; pelvics I, 5–I, 5; caudal rays i + 10 + i; plates along sides 19 + 12, totaling 31; 17 plates from anal base to caudal fin base; teeth when all are present number 7/6 and 7/6 on each ramus; about 21 or 22 barbels along margin of lower lip.

The teeth are exactly as in *S. phelpsi*—long, slender, with spoonshaped bilobed tips, the inner lobe largest; the usual notch at the rear of the orbit in members of the genus *Loricaria* is lacking; the supraoccipital ends in a spiny elevated keel, and the other plates and keels on the back behind the head are essentially as shown on Plate 14 (*l.c.*) for *phelpsi;* other plates along the side of the body are as in *phelpsi;* the belly is only partly covered with platelets, the middle part naked and the platelets confined to the sides of the belly; sides of head with about 150 stiff setiform bristles about as long as or shorter than, interorbital space, these bristles not depressible; upper surfaces of pectoral fins with small spines; anterior forward margin of snout with small spines and middle of snout forward from interorbital space with very numerous small spinules; lips papillate, lower lip with dermal barbels or lappets along its rear margin numbering about 21 or 22; upper lip with a series of barbels along its anterior margin but in a double row for most of the distance; barbel at corner of mouth not quite reaching gill opening; interorbital space deeply concave; space between nostrils very slightly convex; snout bony, the outer margin flaring out a little and covered with numerous short spinules; dorsal fin broken off distally; margin of anal fin rounded; pelvic fin spine not produced beyond tip of first branched pelvic fin ray, the margin of this fin slightly undulating; margin of pectoral fin slightly rounded; spines of pectoral and of anal fins about same length as next branched ray; the dorsal margin of the orbit is elevated and with small spines, this spiny ridge con-

1 Published with the permission of the Secretary of the Smithsonian Institution.
2 Named *atratoensis* after the river system in which it was collected.

tinuing forward to opposite front of nostrils; the cheek forward of eye is concave; the intestine is coiled; the upper ray of caudal fin is elongate, now measuring 160 mm. in length, but the tip is broken off; distal margin of caudal fin a little concave.

TABLE I

MEASUREMENTS MADE ON THE TWO SPECIES OF *Spatuloricaria*
(All measurements expressed in hundredths of the standard length)

Characters	*phelpsi* Rio Socuy, Venezueala	*atratoensis* Rio Truando, Colombia
Length of head to tip of supraoccipital	23.3	24.5
Length of head to end of opercle	18.8	20.4
Length of head to end of posttemporal plate	23.8	25.9
Width of head at base of pectorals	19.5	21.9
Length of snout	13.1	14.5
Diameter of eye	3.50	3.26
Least width of bony interorbital space	5.59	5.62
Greatest depth of body at dorsal origin	13.6	12.7
Width of body across anal fin origin	16.7	16.3
Postorbital (from notch in eye if present) length of head (to end of posttemporal plate)	8.90	8.50
Least depth of caudal peduncle	1.80	1.78
Width of caudal peduncle (3rd from last plate)	4.88	5.15
Length of caudal peduncle	47.6	43.5
Length of last ray of pectoral fin	9.26	7.40
Length of last ray of pelvic fin	10.5	9.62
Length of last ray of anal fin	11.9	11.4
Length of last ray of dorsal fin	10.4	....
Length of spine of dorsal fin	25.6	....
Length of spine of anal fin	17.9	16.7
Length of pelvic spine	17.9	18.8
Length of pectoral spine	20.3	18.6
Distance from tip of snout to dorsal origin	34.2	36.2
Tip of snout to anal origin	48.2	51.5
Tip of snout to insertion of pelvics	32.6	34.6
Tip of snout to insertion of pectorals	18.8	21.3
Anus to anal origin	9.32	11.7

Color in alcohol, pale brownish, lighter below; caudal fin with blackish spots and dark blotches arranged in 3 or 4 irregular bars; anal fin with about 4 rows of dark spots; traces of dark spots remain on pelvic fins.

This new species of *Spatuloricaria* differs from *phelpsi*, known from only one specimen from the Maracaibo Basin, as indicated in the key which follows.

KEY TO THE SPECIES OF *Spatuloricaria*

1a. Width across body at 19th lateral plate contained 5.1 times into distance between base of last dorsal fin ray and end of keel on last lateral plate at base of caudal fin; interorbital space slightly concave or nearly flat with dorsal margin of orbits not elevated; cheek in front of eye flat or nearly so; a small notch at posterior dorsal edge of orbit present; front edge of snout not more spiny than rest of snout and not flaring out to form a ridge ..... *S. phelpsi*

1b. Width across body at 19th lateral plate contained 4.4 times into distance between base of last dorsal fin ray and end of keel on last lateral plate at base of caudal fin; interorbital space strongly concave with dorsal margin of orbits elevated and this spiny elevation continuing forward in front of eye to form an elevated spiny ridge; cheek in front of eye concave; no notch at posterior dorsal edge of orbit; front margin of snout flaring out a little to form a spiny ridge ..... *S. atratoensis*

UNITED STATES NATIONAL MUSEUM, WASHINGTON, D. C.

Some Uses of Nomographs in Fish Growth Studies [1]

By Kenneth D. Carlander and Lloyd L. Smith, Jr.

NOMOGRAPHS have been used in various fish growth studies, (Huntsman, 1918; Lea, 1919; Hile, 1941; Fry, 1943) but it is believed that their usefulness in this field has not been fully realized. The nomograph described in this paper has saved much time in the calculation of growth rates at the fisheries research laboratories of the Minnesota Department of Conservation. This nomograph is easily constructed and may be operated accurately even by relatively unskilled technicians. As here described, it couples the use of cards on which the scale measurements are marked as proposed by Lea (1919) with the simpler form of nomograph used by Hile (1941). When the true body-scale relationship is known, the growth rate is calculated with specially prepared nomograph tables. Huntsman (1918) used a cardboard curve on a nomograph to make calculations when the true body-scale relationship was known. Special nomograph tables are simpler to use than the cardboard curve. Fry (1943) described a nomograph which can be used only for those cases in which the body-scale relationship can be described by a logarithmic straight line. The logarithmic straight line does not satisfactorily describe the body-scale relationship of all fishes (Creaser, 1926; Bennett, Thompson, and Parr, 1940; Carlander, 1944). Nomographs used in growth studies are based on the geometric principle that parallel lines cut proportionate segments off divergent lines (Fig. 1).

Making the Nomograph

Nomographs are made simply and accurately with 0.1 inch cross-section paper. Only the horizontal lines are used, and these lines are numbered from zero to the number of millimeters or tenths of inches representing the maximum length of the fish. Usually if the lines are numbered by single units, the nomograph becomes too large, and, therefore, intervals of 2, 3, 4, or even 8 units are sometimes needed. The interval between two lines must be large enough so that the distance between zero and the number representing the length of a given fish on the nomograph is not as great as the radius (or diameter) of the magnified scale image.[2] On the other hand, the interval should be as small as possible, because the ease and accuracy in using the nomograph decreases as the interval increases. When the interval is 2, the position of one number between each set of lines must be interpolated. When the interval is 8, interpolation must be used for the seven numbers between each set of lines. For ease in reading the nomograph, identical numbers are placed one inch apart on each horizontal line. When completed, the nomograph is mounted and shellacked.

1 The dictionary definition of a nomograph is: "a graph that enables one by the aid of a straight edge to read off the value of a dependent variable when the value of the independent variable is given." Nomographs are used as an aid to calculation in military science, in industry, in engineering (where they are referred to as alignment charts), and in many other branches of science. Whenever a large number of calculations of the same type are to be made, a nomograph may prove a valuable time-saver. Nomographs are of many forms and types, varying greatly in complexity (d'Ocagne, 1921; Werkmeister, 1923; Swett, 1928; Allcock and Jones, 1932; Mavis, 1939), but some of the most useful are very simple in construction and application.

2 If each line is numbered consecutively, the interval is referred to as an interval of one; if the lines are numbered by twos (as zero, two, four, six, eight, etc.), the interval is two; and so forth. Since the space between the lines is 0.1 inch on each nomograph, a large interval makes a smaller nomograph.

Using the Nomograph

Use of the nomograph eliminates the necessity of measuring and recording the radii (or diameters) of the annuli on the scale image. Instead, the positions of the essential scale features may be marked on a strip of Manila tagboard. When radii of the annuli are to be measured, the strip is placed along

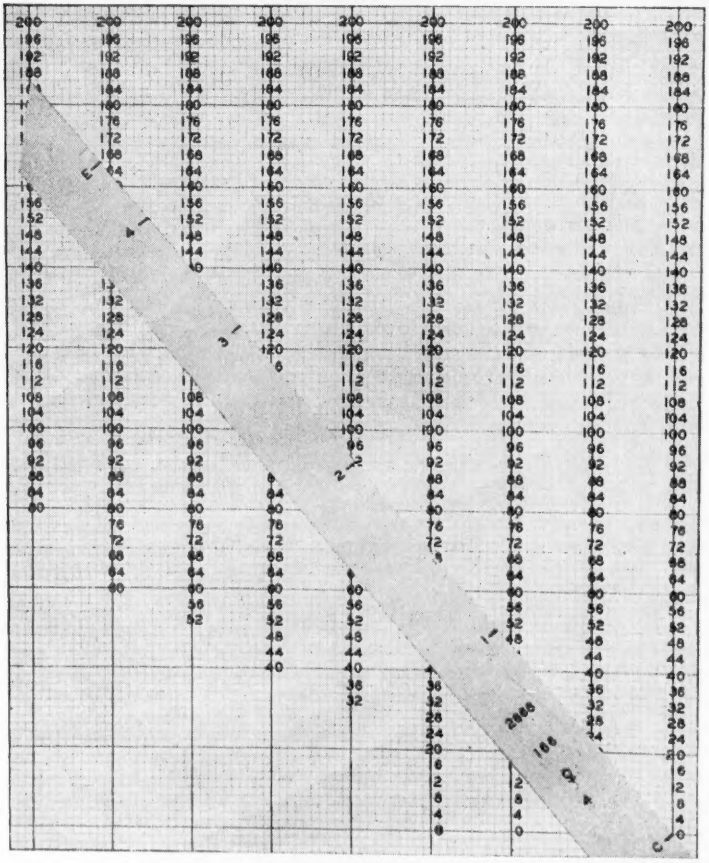

Fig. 1. Direct proportion nomograph with tagboard strip in place for calculating growth from scale measurements. This setting does not include correction for late scale formation. (Nomograph prepared by John Dobie, Minnesota Bureau of Fisheries Research.)

the anterior radius of the scale image, and the position of the focus of the scale is marked on the strip. Without moving the strip, the positions of the various annuli, and of the anterior margin of the scale are also marked. When scale diameters are measured, the first mark is made at the inner annulus on the posterior field, and without moving the strip, the second mark is made

at the inner annulus on the anterior field. The strip is then moved so that the first mark coincides with the second annulus on the posterior field, and the position of the second annulus on the anterior field is marked. This process is repeated for each annulus. Finally, the first mark is made to coincide with the posterior edge of the scale, and the position of the anterior edge is marked. When two scales from each fish are measured to increase accuracy, the two scales are recorded on the two edges of the same strip. The serial number, length, sex, and age of the fish are recorded on the strip for easy reference.

To calculate the growth rate of a fish from the scale measurements, the tagboard strip is placed on the nomograph so that the first mark (C, Fig. 1) is on the zero line of the nomograph, and the mark designating the edge of the scale (E, Fig. 1) is on the line corresponding to the length of the fish (166, Fig. 1). The length of the fish at the time of annulus formation may then be read directly from the nomograph opposite the marks designating each annulus (in Fig. 1 these are: 1st annulus, 50; 2nd annulus, 92; 3rd annulus, 126; and 4th annulus, 153 mm.).

So far, the description has been limited to growth calculations made on a direct proportion basis using the formula:

$$\frac{L_n}{L} = \frac{S_n}{S}$$

where L is the standard length at time of capture; L_n is the standard length at time of annulus formation; S is the scale radius (or diameter); and S_n is the scale radius (or diameter) of annulus.

Various studies have demonstrated that, for many species of fish, the growth of the scale is not directly proportional to body growth. The true body-scale relationship should, therefore, be calculated when detailed life history studies are undertaken. Growth calculations can be made with the nomograph if modifications are made for the corrected body-scale relationship. In some species of fish, the relationship is a straight line with the following formula:

$$L_n = a + \frac{S_n}{S}\ (L - a)$$

when L is the length at capture; L_n is the length at time of annulus formation; a is the length of fish at time scale was formed; S_n is the scale measurement to annulus; and S is the outside scale measurement.

When it is necessary to make this correction, for late scale formation, the growth can be calculated by placing the first mark on the strip on the line corresponding to the value of *a* rather than on the zero line (in Fig. 2, *a* is 16 mm.).

In many species of fish the body-scale relationship can be described by a logarithmic straight line, and Fry's (1943) nomograph may be used. The specialized nomograph described below may also be used in such cases, as well as in many where the body-scale relationship is curvilinear (Creaser, 1926; Carlander, 1944) and cannot be described by any of the above formulae.

Hile (1941) determined that the mathematical relationship between standard length (L) and scale measurements (S) of rock bass, *Ambloplites*

rupestris rupestris (Rafinesque), in two Wisconsin lakes could be expressed as follows:

$$\text{Log } L = 0.7664210 + 0.695992 \text{ Log } S$$

Solution of this formula gave the theoretical or "normal" scale measurement (S) for each standard length (L). A table of these "normal" scale

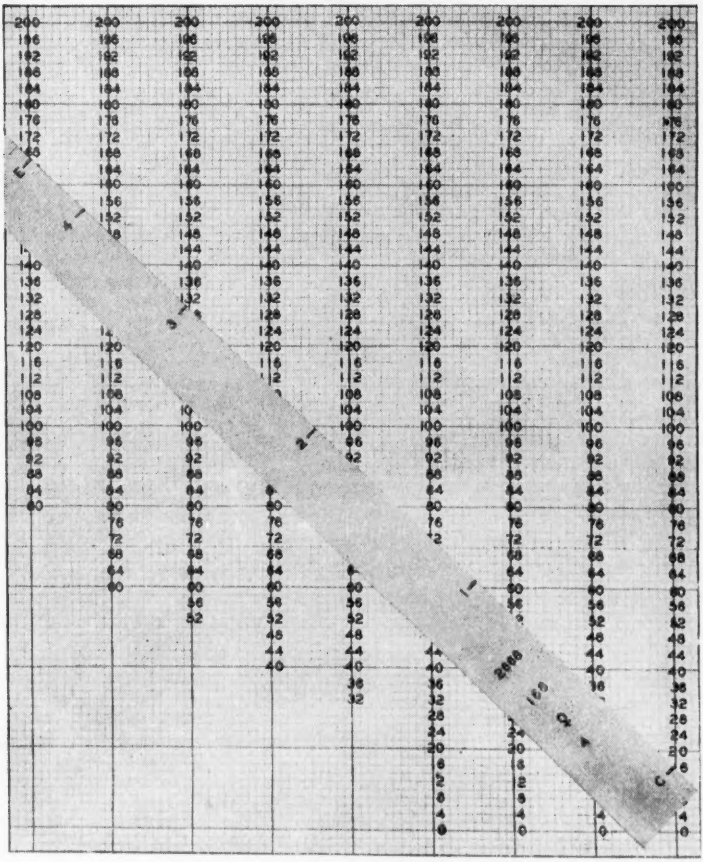

Fig. 2. Direct proportion nomograph with tagboard strip in place for calculating growth from scale measurements. This setting assumes that scale was formed when fish was 16 mm. long. (Nomograph prepared by John Dobie, Minnesota Bureau of Fisheries Research.)

measurements was prepared. In calculating the growth of a given fish, the "normal" scale measurement for a fish of that length was determined from the table, and that "normal" measurement was divided by the actual outside measurement of the scale from the fish. The scale measurements to each an-

nulus were then multiplied by this quotient. These "corrected" scale measurements were then converted to the corresponding body lengths by referring again to the table.

Hile's method of computation may be used whenever the true body-scale relationship is determined. The calculations of growth rates by this method can be greatly simplified with specially prepared nomographs. In making these special nomographs, the horizontal lines must first be considered as representing the "normal" scale measurements, but the lines are not marked with these numbers. Instead, the lengths corresponding to the "normal" scale measurements (from the table of solutions) are marked on the lines. The nomograph is then used in the same way as a direct proportion nomograph, and the corrected lengths may be read directly from the nomograph, opposite the marks on the tagboard strip. Reference to the table of solutions is thus eliminated. When a sample includes more than 50 fish, the construction of a special nomograph will result in a saving of time.

It is believed that nomographs will become more important tools in fisheries research as their value is appreciated. They are simple to construct and convenient and accurate to use.

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Species of the Circumtropical Fish Genus *Brotula*

By CARL L. HUBBS

THE Brotulidae are blennioid fishes, which, with few exceptions, are inhabitants of the deep sea (Goode and Bean, 1895: 314–344; Radcliffe, 1913: 135–175; Norman, 1939: 76–92). The few species that live in the littoral and sublittoral belts along tropical shores are mostly referable to two subfamilies. These groups are the Brosmophycinae, which also dwell in the fresh-water caves of Cuba and Yucatan (Hubbs, 1938: 287–291), and the Brotulinae. The typical subfamily, comprising the one genus *Brotula*, is characterized by the development of rostral and mandibular barbels, numbering 12 in all. This genus is revised in the present paper.

Three species of *Brotula* appear to be valid. These are *B. barbata* (Bloch and Schneider) of the western Atlantic, *B. clarkae*, new species, of the eastern Pacific, and an Indo-Pacific form, *B. multibarbata* Temminck and Schlegel, which has been described under numerous names. The ranges of the 3 allopatric species are charted according to record stations on Figure 1.

Much of the work on this paper was done at the United States National Museum, where the pertinent collections were generously placed at my disposal by Dr. Leonard P. Schultz, Curator of Fishes. Subsequently Dr. Robert R. Miller, newly appointed Associate Curator, examined for me at the National Museum certain publications that were not available in Ann Arbor. The two relatively enormous types of *B. clarkae*, from Lower California, were made available by Dr. Frances N. Clark, of the California State Fisheries Laboratory. Mr. Gerhard Bakker, Jr., then working at the Laboratory, kindly drew the outline figure of the holotype (Fig. 2), and Mr. Norman J. Wilimovsky, a student assistant at the University of Michigan, prepared the distributional map (Fig. 1). Laura Clark Hubbs assisted in the investigation.

METHODS OF COUNTING AND MEASURING

The methods which I followed in counting and measuring *Brotula* were those recommended by Hubbs and Lagler (1941: 12–20, figs. 2–3). A few points need special consideration.

The fin rays could not be counted with precision until the thick, loose skin was slit. In agreement with the general rule, the last two radial elements in the dorsal and anal fins were treated as one ray. The line of division between the dorsal and caudal rays and between the anal and caudal rays was somewhat arbitrary, even though it was determined by dissection. The caudal rays were separately enumerated above and below the mid-line.

Since they are very irregularly arranged the scales were difficult to count,

but the distinction between the relatively large scales of the Indo-Pacific species and the small scales of the American ones, particularly of *B. clarkae*, was obvious at sight. In counting the series from the origin of the dorsal downward and backward to but not including the lateral line and from the anal origin upward and forward to the lateral line, the very small scales on the base of the fins were not included. The strongly oblique transverse scale rows were counted just above the lateral line, from the hard edge of the post-temporal region to the end of the hypural. Interpolated scales or rows starting only a scale or two above the lateral line were not included.

Measurements were consistently made on the left side, except that the longer pelvic fin was measured.

GENUS *Brotula* CUVIER

Brotula.—Cuvier, 1829: 335 (original diagnosis; haplotype, *Enchelyopus barbatus* Bloch and Schneider). Günther, 1862: 371 (description). Gill, 1863: 252 (diagnosis). Day, 1878: 419 (description). Goode and Bean, 1895: 314 (in key). Jordan and Evermann, 1898: 2498, 2500 (comparison; description); 1905: 506–507 (description). Günther, 1909: 331 (diagnosis). Radcliffe, 1913: 136, and Norman, 1939: 84 (in keys). Also of authors in general (for references see synonymies of species).

Nematobrotula.—Gill, 1863: 252 (original diagnosis; orthotype, *Brotula ensiformis* Günther). Goode and Bean, 1895: 314 (in key).

Geneiates.—Tickell, MS, in Day, 1888: 804 (*Geneiates ferruginosus* Tickell, MS, listed in synonymy of *Brotula multibarbata*).

The genus *Brotula* is a small and compact unit, so trenchantly distinguished from other Brotulidae as to justify its separation in the monotypic subfamily Brotulinae. Cuvier (1829) knew only the type species, *B. barbata*. Temminck and Schlegel (1846), and others writing about the middle of the last century, interpreted *Brotula* as equivalent to the whole family, and Day as late as 1888 included in *Brotula* a new species, *B. jerdoni*, which apparently lacks barbels. The genus was properly restricted by Kaup (1857), Günther (1862), Gill (1863), and recent authors to species bearing barbels on the snout and on the mandible.

The genus *Nematobrotula* Gill was distinguished solely on the basis of the supposedly entire pelvic fin of *B. ensiformis*, a nominal species which I regard as a synonym of *B. multibarbata*. It was made clear by Günther (1873: 267, and 1909: 333), however, that he had at first erred in describing the dry-skin type of *B. ensiformis* as having an undivided filament. In all specimens of the genus which I have examined the 2 pelvic rays have a common membranous investment basally but are free distally for a greater or lesser extent. The free filaments, which are subject to injury, vary greatly in length and often differ markedly in the two fins. Longley (in Longley and Hildebrand, 1941: 276) correctly stated that the pelvic fin of *B. barbata* is not a single bifid ray, as it had been held to be, but he erred in counting 3 rays. On examining Longley's dissection I find that what he mistook for an extra ray is merely the slightly exposed outer edge of the lower half of the first ray.

The manuscript name *Geneiates* has been overlooked in all compilations of generic names. It is a semiobjective synonym of *Nematobrotula*, for the respective type species are synonymized. I see no grounds whatever for the separation of either *Geneiates* or *Nematobrotula* from *Brotula*, nor for the generic distinction of the new species *B. clarkae*.

Analysis of the Species of *Brotula*

The species of *Brotula* have never been distinguished adequately. Most of the characters which have been used are false or unreliable. Valid specific differences, largely overlooked, lie in the shape of the vomerine tooth patch; in the coloration, particularly of the vertical fins; in the size and shape of the head; in the size and number of scales; and, on the average, in the number of fin rays, particularly in the pectoral fin. The three species which I recognize are readily distinguishable according to the following key.

1a.—Vertical fins dark, becoming gradually darker at the extreme blackish edge. Head larger, in half-grown and adult 0.23 to 0.28 of standard length; its profiles evenly merging into those of the body in both dorsal and lateral views. In half-grown and adult, distance from tip of snout to anal origin 0.47 to 0.54 of standard length; length of upper jaw 0.11 to 0.13. Dorsal rays 108 to 117; anal rays 78 to 94, usually fewer than 90; pectoral rays 25 to 28. Scales 19 to 30—188 to 225—53 to 75. *New World species*

2a.—Vomerine teeth forming three large rounded patches, with a rather broad commissure between the anterior patch and each posterior group. Vomerine and palatine teeth in young in very narrow bands. Lower part of head in adult deeply pigmented. Head 0.22 to 0.24 of standard length. Width of pectoral base 0.050 to 0.058 of standard length. Pectoral rays 25 or 26. Scales 19 to 23—188 to 210—53 to 59. *Western Atlantic* ..... *B. barbata*

2b.—Vomerine teeth in a very narrow V-shaped band, becoming strongly U-shaped at apex. Vomerine and palatine teeth of young uniserial. Lower part of head, including lips, whitish (pink in life). Head 0.24 to 0.28 of standard length. Width of pectoral base 0.060 to 0.067 of standard length. Pectoral rays 27 or 28. Scale 25 to 30—222 to 225—59 to 75. *Eastern Pacific* ..... *B. clarkae*

1b.—Vertical fins light, except for black submarginal band, with extreme edge whitish. Head smaller, in half-grown and adult 0.19 to 0.22 of standard length; rather abruptly slenderer and narrower than body. In half-grown to adult, distance from tip of snout to anal origin 0.42 to 0.47 of standard length; length of upper jaw 0.09 to 0.11. Dorsal rays 109 to 139 (to 158?); anal rays 80 to 106 (to 117?), usually more than 90; pectoral rays 22 to 26, usually fewer than 25. Scales 11 to 18—136 to 181—33 to 49. *Indo-Pacific species*

2c.—Vomerine teeth in a moderately broad V-shaped band, with rounded apex. Vomerine and palatine teeth of young in very narrow bands ...*B. multibarbata*

Systematic Account of the Species

The three species which I recognize in the genus *Brotula* are treated, with their synonymies, on the following pages.

Brotula barbata (Bloch and Schneider)

Brotula.—Parra, 1787: 70–71, pl. 31, fig. 2 (description; presumably Cuba).

Enchelyopus barbatus.—Bloch and Schneider, 1801: xxvi, 52–53 (synonymy; description, after Parra). Cuvier, 1829: 335 (only species of *Brotula* Cuvier).

Brotula barbata.—Guichenot, 1843: 233 (synonymy; Cuba). Temminck and Schlegel, 1846: 251 (comparison). Guichenot, 1855: 164 (synonymy; Cuba). Kaup 1857: 92 (listed). Poey, 1860: 102–104, pl. 9, fig. 2 (synonymy; description; Havana, Cuba). Günther, 1862: 371 (synonymy; description; Caribbean Sea). Poey, 1863: 179 (synonymy); 1867: 168–169 (supplementary description); 1868: 401 (notes and characters); 1876: 179 (synonymy and notes). Goode, 1877: 291 (Bermuda). Bean and Dresel, 1884: 152 (Jamaica). Gill, 1884: 175 (group characters). Jordan, 1886: 51 (Havana, Cuba). Cockerell, 1892: 13 (Jamaica). Jordan and Evermann, 1898: 2500 (synonymy; description; range; Havana); 1900: 3306, pl. 354, fig. 871 (Cuba). Bean, 1906: 86 (Ber-

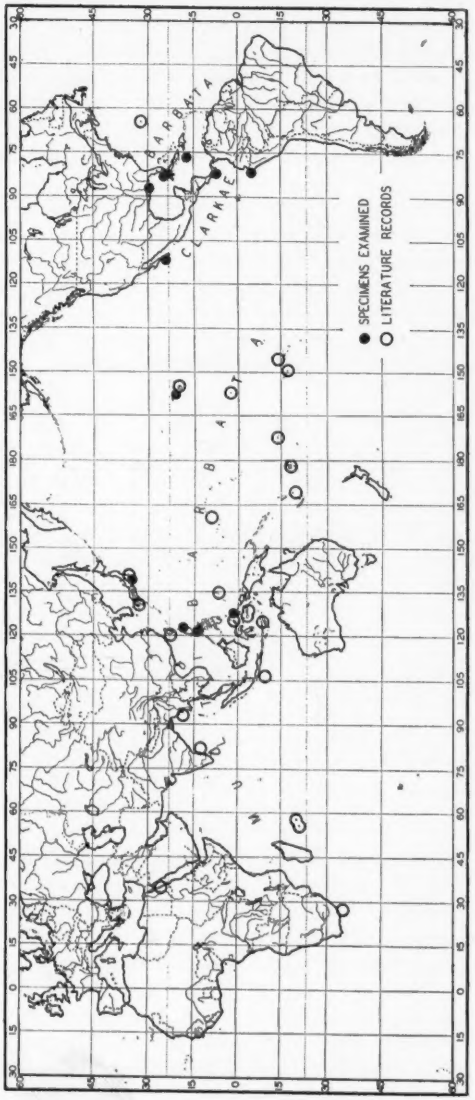

Fig. 1. Distribution of the three allopatric species of *Brotula*.

All the Indo-Pacific records referred to *B. multibarbata*. One record, for a specimen examined from Hull Island (approximately Lat. 5° S., Long. 172° W.), was inadvertently omitted. There is also a report for New Guinea. Other data may have been overlooked. The authorities for the literature records can be traced through the synonymies.

muda). Günther, 1909: 334 (vertebrae). Evermann and Radcliffe, 1917: 152 (*maculata* distinct). Beebe and Tee-Van, 1933: 230, 1 fig. (range; description; Bermuda). Longley and Hildebrand, 1941: 276–277 (Tortugas, Florida; range; characters).

According to Bloch and Schneider (1801: xxvi), quoted by Poey (1860: 103), this species was probably described prior to 1787 by the non-Linnaean authors Duhamel and Hermann (or Herrmann). Their descriptions, however, appear to have no bearing on the scientific nomenclature of *Brotula barbata*. According to Günther (1862: 37) Hermann identified this fish as a species of *Gadus*.

There is apparently only one Atlantic species of *Brotula*. Beebe (1937: 206), to be sure, listed "*Brotula* spp." from 700 to 900 fathoms off Bermuda, on the basis of 8 young specimens 7 to 50 mm. long. He now informs me, however, that this record refers to brotulid material that was unidentified either to genus or species.

TABLE I

COUNTS AND MEASUREMENTS OF *Brotula barbata*

Data for the specimens are listed below.

Cat. No. (USNM)	32759	5337	116871	32054	12563
Counts					
Dorsal rays	117	112	112	114	113
Anal rays	94	86	86	88	87
Caudal rays, upper	4	4	5	6	6
Caudal rays, lower	5	5	5	4	5
Pectoral rays	26	26	25	26	25
Scales above lateral line	..	19	23	20	20
Scales along lateral line	..	195	202	210	188
Scales below lateral line	..	59	56	56	53
Standard length, mm.	61.5	285	332	538	543
Thousandths of standard length					
Snout to anal origin	459	466	492	508	530
Body depth	163	200	170	199	194
Head length	222	234	244	236	228
Upper jaw length	107	114	119	116	118
Snout length	41	54	53	57	57
Orbit length (fleshy)	56	48	47	43	43
Interorbital (fleshy)	33	42	36	36	38
Longest pectoral ray	144	91	111	118	101
Pectoral base	58	55	50	51	52
Longest pelvic ray	125	121	109	130	141
Caudal fin length	98	75	85	73	61

In a young specimen 61 mm. long from Pensacola, Florida (USNM 32759), the teeth of the jaws are in very narrow bands, and are somewhat enlarged in the innermost file. Relatively large vomerine and palatine teeth in one series, together with a few additional teeth on the outside, form narrow bands. Obviously the teeth become much more numerous and blunter with age, as the width of each band increases. This specimen exhibits the pattern of giant melanophores that characterizes the young of all species of the genus.

Counts and measurements of the 5 specimens of *B. barbata* examined in the National Museum are given in Table I. The distribution records for the species are plotted on Figure 1. Data for the specimens are as follows: 32759, Pensacola, Florida; Silas Stearns. 5337 and 12563, Cuba; Poey. 116871, Tortugas, Florida; W. H. Longley. 32054, Jamaica; Jamaica Institute.

Brotula ***clarkae,*** new species

Brotula maculata (homonym of *Brotula maculata* Day, 1868).—Evermann and Radcliffe, 1917: 151–152, pl. 13, fig. 3 (original description; Paita, Peru).

TYPES.—The holotype, Cat. No. 141263, Museum of Zoology, University of Michigan, is the largest known specimen of the genus. It is an adult 780 mm. long to caudal base (810 mm. long before preservation). It was collected with a 762 mm. paratype, UMMZ 141264, on June 6, 1943. These two fish, along with another of similarly large size that was not saved, were found floating on the surface of the Pacific Ocean 5 miles south of Cape San Lazaro, just north of Magdalena Bay, Lower California, by a commercial fisherman, Frank Fowlow, while engaged in "rock cod" (*Sebastodes*) fishing with lines, on the boat "Loren F." The fish appeared stunned but were not dead, and it was suspected that they had been injured by some "submarine explosion."

There are two paratypes of *B. clarkae* in the National Museum. One of these, No. 77702, the holotype and only recorded specimen of *B. maculata* Evermann and Radcliffe, is from Paita, Peru. No. 94042 is a juvenile specimen 72.5 mm. long, dredged by Waldo L. Schmitt at Station 250 of the Galápagos Expedition, from 25 fathoms, on a bottom of mud and dead shells, south of the Secas Islands on the Pacific Coast of Panamá, on February 22, 1934.

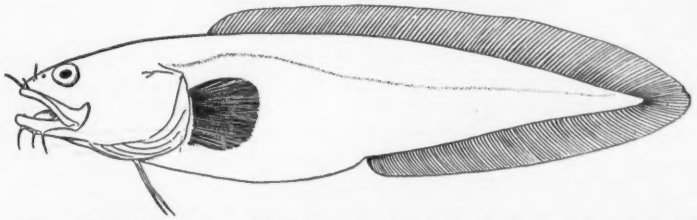

Fig. 2. *Brotula clarkae,* sketched by Gerhard Bakker, Jr., from the holotype, prior to its preservation. Standard length, 780 mm.

DESCRIPTION.—The general form of the body, head, and fins of the adult is shown in Figure 2. The trunk region is particularly massive. The anterior parts are moderately compressed (the width of the head enters the head length about 2.1 to 2.3 times); posteriorly the body becomes very strongly compressed. The head, unlike that of *multibarbata,* is large and has contours which grade evenly into those of the body, so that the head does not appear pinched in, either in lateral or in dorsal view. The opercular spine is very strong, and ends a snout's length in advance of the tip of the opercular membrane.

The barbels are arranged as in the other species of the genus. On each side there are three on the snout and three on the mandible. Probably as a result of injuries the anterior rostral barbel of the paratype is lacking on the right side and is widely forked on the left. In the holotype the anterior rostral

barbel of the right side is forked at the extreme tip and is 0.9 as long as the orbit, whereas the corresponding barbel on the left side is only two-thirds that length. The base of this barbel bears a fleshy protuberance at the outer angle and near by, in the fold of the upper jaw, there is a pair of large papillae or very short barbels. The second rostral barbel also arises near the edge of the rostral fold, and is forked on the left side in the holotype. It is about two-fifths to one-half as long as the orbit. A conspicuous pore lying between these two barbels is closed by a fleshy flap, which might be regarded as a very stumpy barbel. A similar pore behind the second barbel has no such flap. Another pore, more slit-like, occurs on the rostral edge at a distance behind the posterior barbel equal to two-fifths the orbital length. The third rostral barbel arises from the posterior rim of the anterior nostril. It is forked at the tip on the left side of the holotype. Its length varies from a little more than a third to nearly half the orbit. The most anterior and the most posterior of the mandibular barbels arise near the fold of the lower lip and are about two-thirds to three-fourths as long as the orbit, whereas the shorter median one has its base near the inner edge of the mandibular ramus. There is a pair of pores near the tip of the mandible and another pair, closer together, on the chin between the anterior mandibular barbels. There is another large pore on each mandible, between the first and second barbels. The posterior nostril is a large orifice about one-sixth as long as the orbit.

The least suborbital width enters the orbit about 1.7 times. The jaws are about equal. The maxillary is heavy and strongly dilated posteriorly. Its greatest width exceeds the length of the orbit.

The small and somewhat blunt teeth form bands on the jaws, vomer, and palatines. The bands on the jaws are narrow but comprise many rows of teeth. At the widest point, the width of each band is about one-third the length of one arm of the vomerine patch. The teeth on the vomer are in a relatively narrow band which forms a V, with arms that diverge strongly and become somewhat broadened toward their posterior ends. Anteriorly the patch becomes somewhat widened to form a very broad U. At the narrowest point, submedially, the width of the vomerine band is only about one-fourth that of the palatine band, whereas in *barbata* the vomerine band is about two-thirds as wide as the palatine. The tongue is sharply pointed anteriorly.

The expansive branchiostegal membranes are free to below the middle of the eye. The well-developed gill-rakers of the outer series on the first arch comprise one at the angle and two below, each about half as long as the orbit. These are smooth on the outer surface but are covered with very fine teeth on the inner face. The other gill-rakers are finely-toothed stumps and plates, numbering 5 or 6 above the angle and 14 to 16 below the developed rakers, with some extra ones interpolated between the main rakers and elsewhere. There is a large slit behind the last gill. The pseudobranchiae are conspicuous. There is a deep recess from the gill cavity, at the posterior end of the mandible. The air bladder is an extremely hard-walled organ, as it is in the other species.

As is characteristic of the genus the lateral line is a rather diffuse structure most obvious as an irregular dark streak. It ends, as in the other species,

nearer the dorsal than the ventral contour, at a point about the length of the orbit or of the snout in front of the end of the hypural.

The fish in alcohol are colored much as they were when fresh (see description below). The buccal and branchial cavities have dark linings. At no age do the fins show the submarginal black band and extreme white edge that is characteristic of *multibarbata*.

The foregoing description is based on the two very large types from Lower California. In essential features it has been checked on the type of *B. maculata* from Peru. Counts and proportional measurements of the four known specimens are given in Table II.

TABLE II

COUNTS AND MEASUREMENTS OF *Brotula clarkae*

Museum	USNM	USNM	UMMZ	UMMZ
Cat. No.	94042	77702	141264	141263
Type status	Paratype (young)	Type of *B. maculata*	Paratype (large adult)	Holotype (large adult)
Counts				
Dorsal rays	...	108	112	111
Anal rays	...	78	89	83
Caudal rays, upper	...	6	6	6
Caudal rays, lower	...	5	5	5
Pectoral rays	...	27	28	28
Scales above lateral line	...	25	28	30
Scales along lateral line	...	222	224	225
Scales below lateral line	...	75	65	59
Standard length, mm.	72.5	405	762	780
Thousandths of standard length				
Snout to anal origin	449	479	541	541
Body depth	159	181	234	226
Head length	242	260	277	265
Upper jaw length	108	122	126	125
Snout length	43	53	59	52
Orbit length (fleshy)	55	44	42	41
Interorbital (fleshy)	42	40	47	46
Longest pectoral ray	165	111	126	117
Pectoral base	65	60	65	67
Longest pelvic ray	152	114	111	108
Caudal fin length	99	75	75	...

The characters of the young are indicated by the specimen 72.5 mm. in standard length collected near the Secas Islands, Panamá. Compared with the adult it is found to differ markedly in proportions: the body is much slenderer, the head and trunk much shorter, the eye larger and the snout shorter, and the fins much more expansive (Table II). The teeth of the jaws are in very narrow instead of moderately broad bands, and those of the inner file are enlarged. The teeth of the outer row in the premaxillary are less obviously enlarged than in the young of *barbata*. The bands of jaw teeth are much narrower than in the young of *multibarbata*. The vomerine teeth exhibit the pattern of the adult, as they are arranged in a V which abruptly becomes U-shaped at the apex. This apical U is much more prominent than in the young of *barbata*. The vomerine and palatine teeth are uniserial rather

than being in very narrow bands as they are in young of like size of the two other species.

This young specimen of *clarkae* resembles the young of *barbata* and *multibarbata* in pigmentation. Below and behind the eye most of the cheek is occupied by a dusky area, in which conspicuously enlarged melanophores occur. There are many giant melanophores in a single series along the base of the dorsal fin and a few along the anal base. There is also a trace of the large melanophores on the body, which were described or figured by Fowler (1932: 13, fig. 2) and Schultz (1943: 288) for the young of *B. mülleri* (=*B. multibarbata*), by Day for the young types of *B. maculata,* and by Smith for the juvenile type of *B. palmietensis.* A similar pattern is exhibited by the young specimen of *B. barbata* from Pensacola, and is doubtless characteristic of the genus.

The two giant types when received at San Pedro, after lying for 15 days on ice, were warm purplish brown over most of the body. The lower half of the head, including the lips, was white with a strong wash of orange-pink. This color also extended over the barbels and the pelvic fins. The pectorals were dusky pinkish, becoming clearer near the edge. The brownish vertical fins gradually darkened toward the margin, which became blackish near the end of the dorsal fin, on the caudal, and along the whole length of the anal. No whitish edge, like that of *multibarbata,* appeared either in the fresh or preserved state. A rather sooty streak followed the course of the lateral line.

I take real pleasure in naming this species for Dr. Frances N. Clark, accomplished fisheries researcher of the California State Fisheries Laboratory.

Brotula multibarbata Temminck and Schlegel

Brotula multibarbata.—Temminck and Schlegel, 1846: 251–253, pl. 111, fig. 2 (original description; Simabara Bay, Japan). Kaup, 1857: 92 (listed). Bleeker, 1857: 75 (Boeroe); 1858: 22–24 (comparisons; Amboina and Boero); 1860: 46 (Tanawanko, Celebes). Günther, 1862: 371–372 (Japan; Celebes; Amboyna; Booroo). Bleeker, 1863: 272 (Atap, Timor); 1865a: 150 (Bouro); 1865b: 294 (Amboina). Schmeltz, 1869: 24 (Savay [presumably Savaii, Samoa]). Klunzinger, 1871: 574 (description; Koseir, Red Sea). Bleeker, 1879: 20 (Nagasaki, Kiusiu). Steindachner and Döderlein, 1887: 280 (comparisons). Day, 1888: 804 (description; Saddle Island off Kyoukphoo, Arracan; Madras). Steindachner, 1896: 216 (description; synonymy; Kobe, Hiogo, or Nagasaki, Japan). Jenkins, 1901: 404 (comparison). Regan, 1903: 461, fig. 1A (skull [later made a type of *B. jayakari*]); 1909: 406 (Christmas Island [Indian Ocean]). Günther, 1909: 332 (description; Japan; Celebes; Amboyna; Booroo). Jordan and Richardson, 1909: 204 (Takao, Formosa). Jordan, Tanaka, and Snyder, 1913: 403 (*B. japonica* a synonym; Tokyo to Formosa; Celebes; Amboina; Buru). Fowler, 1922: 84 (Hawaii); 1925: 30 (Honolulu); 1927: 32 (Honolulu; abortive tail); 1928: 445 (synonymy; description; Japan; Honolulu). Satô, 1937: 274, 276 (number and histology of barbels; Simoda, Sagami, or Suruga Bay, southern Japan). Fowler, 1938: 115–116, 301 (description; Takaroa, Tuamotus; Honolulu). Okada, 1938: 261 ("Honsyu—Taiwan (Formosa), Celebes, Amboina, Buru"). Okada and Matsubara, 1938: 410 (records repeated).

Brotula burbonensis.—Kaup, 1857: 92 (original description [Bourbon (=Reunion) Island, Indian Ocean]). Günther, 1862: 372 (description, after Kaup; Bourbon); 1909: 336 (diagnosis, after Kaup; Reunion).

Brotula ensiformis.—Günther, 1862: 372 (original description; Aneiteum). Gill, 1863: 252 (type of *Nematobrotula,* new genus). Day, 1868: 196 (comparison). Günther,

1873: 26 (opercular spine; pelvic fin split). Schmeltz, 1877: 17 (Pelew [Palau] Islands). Day, 1878: 419 (comparison). Pöhl, 1884: 38 (Pelew Islands). Steindachner, 1896: 216 (status). Günther, 1909: 333 (description; "Aneitum; ? Mauritius"). Fowler, 1928: 445 (synonymy; description, after Günther; "Mauritus, Melanesia"). McCulloch, 1929: 355 ("Queensland?; East Indies; Aneiteum, New Hebrides"). Fowler, 1931: 364 (Pelew Islands). Herre, 1931: 14 (New Hebrides).

Nematobrotula ensiformis.—Jordan and Seale, 1906: 436 (synonymy; Aneiteum, New Hebrides).

Brotula maculata.—Day, 1868: 196 (original description; Madras); 1878: 419, pl. 91, fig. 2 (description; Madras). Günther, 1909: 332–333 (description; Madras; New Guinea). Cockerell, 1913: 76, and 1916: 319–320 (scales; Madras). Fowler, 1928: 445 (description, after Günther; range).

Brotula multicirrata.—Vaillant and Sauvage, 1875: 282 (original description; Sandwich Islands). Jordan and Snyder, 1904: 946 (*B. townsendi* a synonym; Honolulu). Jordan and Evermann, 1905: 508 (synonymy; description; Honolulu). Jordan and Seale, 1906: 436 (synonymy; Hawaii). Günther, 1909: 335 (description; Sandwich Islands). Jordan and Jordan, 1922: 83 (rare, Hawaii),

Geneiates ferruginosus.—Tickell, MS, in Day, 1808: 804 (in synonymy of *Brotula multibarbata;* comparison; Saddle Island off Kyoukphoo, Arracan, India).

Brotula japonica.—Steindachner and Döderlein, 1887: 279–280 (original description; comparison; Tokio).

Brotula townsendi.—Fowler, 1900: 518–519, pl. 20, fig. 3 (original description; Sandwich Islands). Günther, 1909: 335 (status).

Brotula marginalis.—Jenkins, 1901: 403–404, fig. 16 (original description; comparison; Honolulu). Brigham, 1902: 21 (Hilo, Hawaii). Jenkins, 1903: 510 (reference). Snyder, 1904: 536 (description; Honolulu). Jordan and Evermann, 1905: 507, fig. 225 (description; Honolulu). Jordan and Seale, 1906: 436 (Hawaii). Günther, 1909: 335 (discussion of characters; Honolulu). Jordan and Jordan, 1922: 83 (scarce, Hawaii).

Brotula formosae.—Jordan and Evermann, 1902: 364–365, fig. 27 (original description; Formosa). Jordan and Richardson, 1909: 204, fig. 29 (reference).

Brotula jayakari.—Günther, 1909: 334 (*B. multibarbata* Regan, 1903; original description; Indian Ocean).

Brotula mülleri.—Günther, 1909: 334–335 (original description; Ponapé; Tahiti). Fowler, 1932: 13, fig. 5 (description of young; Suva, Fiji Islands); 1938: 301 (Tahiti).

Brotula mulleri.—Fowler, 1928: 445 (description and records, after Günther). Herre, 1932: 6 (Tahiti). Fowler 1934: 447 (Suva, Fiji Islands). Schultz, 1943: 288 (description of young; coral reef, Hull Island).

Brotula palmietensis.—Smith, 1935: 220–221, pl. 21, fig. C (original description, of young; rock pool, Great Fish Point, South Africa).

An imperfect understanding of the specific characters has led to a multiplication of the nominal species of *Brotula* in the Indo-Pacific region. Several of the forms were based on dried skins which did not display the characters correctly.

The number of barbels has been stressed as a specific character, but all the species probably have 12 barbels, 3 above the mouth and 3 below on each side. Close scrutiny may be required to detect each barbel, and it is no source of surprise that wrong counts were taken from dried skins. Occasionally a barbel may have become lost through injury, as it has in one specimen of *B. clarkae*. *Brotula barbata* was described by Parra and by Bloch and Schneider as having 2 superior and 3 inferior barbels on each side, but Poey gave correct counts. Several variant counts were published for synonyms of *B. multibarbata,* as is indicated below.

Large variations in dorsal and in anal ray counts actually exist in each species, but the greater differences indicated in the literature are attributable

to the impossibility of making precise counts without slitting the tough, loose skin over the fin. Thus Hildebrand counted about 80 dorsal and about 70 anal rays in a specimen of *B. barbata* from Tortugas, whereas after a dissection I find the real counts to be 112 and 86 respectively. Presumed miscounts in *B. multibarbata* have led to a multiplication of nominal species.

Individual and age differences in proportions are rather wide (Table III), and the apparent discrepancies have no doubt been accentuated by differences in preservation and in methods of measuring. The interorbital width has been given some attention in discriminating nominal species in the Indo-Pacific region, but since the fleshy margin of the interorbital is subject to changes on preservation and since the interorbital becomes relatively broader with age, the proportional measurements vary greatly.

Two nominal species (*maculata* and *palmietensis*) have been based in part on the juvenile coloration, also described for the young of "*B. mülleri*" by Fowler and by Schultz. That this coloration is characteristic of the juvenile stage is confirmed by the discovery that a similar arrangement of giant melanophores features the young of *B. barbata* and of *B. clarkae* as well as the juveniles of the Indo-Pacific species.

In the lack of adequate series individual variations in proportions, as of depth and head, have been given undue weight. Marked changes with age in proportions and coloration have been mistaken for specific differences. Single specimens or very small series from distant localities have been given names. As a result identification on the basis of the literature became almost hopeless and authors dropped into the habit of erecting new species for other restricted samples from new regions, until *Brotula multibarbata* was renamed 12 times.

The status of the various nominal Indo-Pacific species may now be discussed. For references, see the preceding synonymy.

Brotula multibarbata was well described and figured by Temminck and Schlegel, but they obviously undercounted the fin rays, as totalling only 186 in the dorsal, anal, and caudal fins. Subsequently this species has been recorded from a number of localities between the Red Sea and the East Indies, as well as from Japan and Formosa.

Brotula burbonensis was based on one dried skin, and its only tangible character, a total of 4 mandibular barbels on both sides, is readily explained on the assumption that Kaup overlooked the median barbel on each ramus.

Brotula ensiformis has little basis for recognition, since it has been shown that the pelvic fin is not, as was originally described, an undivided filament. Günther maintained the species in 1909, on the basis of selected, high counts of dorsal and anal rays. His count of 158 dorsal rays for a specimen from Mauritius is doubted.

Brotula maculata Day merely represents the young of *B. multibarbata*, for in coloration and proportions it matches the other known young of this species. The peculiar pigmentation, as noted before, is a common feature of the young of all the species.

Brotula multicirrata was described as having 8 barbels on the snout, instead of 6. No similar specimen has appeared, though a number of samples of *Brotula* have been collected in Hawaii. Possibly the type was misdescribed,

or perhaps the large flap, described (p. 168) as closing a pore on the snout rim of *B. clarkae,* may have been counted as a barbel. I think that Fowler

TABLE III

COUNTS AND MEASUREMENTS OF *Brotula multibarbata*

Averages in parentheses.

Locality	Hull Island	Halmahera	Philippines	Hawaii	Japan
Specimens	1	1	4	7	3
Counts					
Dorsal rays	123[1]	124	109–130 (117)	117–139 (123)	110–126 (117)
Anal rays	103[1]	100	89–102 (92)	97–106 (100)	80–101 (88)
Caudal rays, upper	...	4	5–6 (6)	4–6 (5)	4–5 (5)
Caudal rays, lower	...	5	4–6 (5)	3–5 (5)	4–5 (4)
Pectoral rays	...	24	22–24 (23)	23–26 (24)[2]	24–25 (24)
Scales above lateral line	...	13	11–15 (13)	12–16 (14)[2]	13–18 (16)
Scales along lateral line	...	162	136–174 (154)	144–181 (156)	157–173 (165)
Scales below lateral line	...	38	33–49 (39)	36–43 (40)[2]	44–47 (45)
Standard length, mm	55	146	137–210 (179)	274–351 (315)	343–414 (382)
Thousandths of standard length					
Snout to anal origin	385	427	423–449 (435)	439–461 (449)	447–469 (458)
Body depth	132	170	158–193 (174)	191–228 (210)	189–210 (201)
Head length	214	195	190–216 (200)	198–214 (206)	197–218 (211)
Upper jaw length	96	90	87–103 (95)	94–107 (100)	96–115 (106)
Snout length	50	44	40–51 (46)	48–56 (52)	50–57 (54)
Orbit length (fleshy)	53	47	40–52 (46)	38–45 (42)	37–48 (44)
Interorbital (fleshy)	31	28	27–36 (33)	32–37 (35)	34–42 (39)
Longest pectoral ray	97	78	90–91 (91)	83–101 (91)	88–108 (98)
Pectoral base	45	42	43–48 (46)	51–57 (54)	54–64 (59)
Longest pelvic ray	137	132	129–146 (139)	111–133 (122)	90–122 (108)
Caudal fin length	60	58	58–70 (66)	51–61 (57)	56–71 (62)

1 Counts taken from Schultz (1943: 288). When I examined the specimen in 1944, a precise count did not seem to be obtainable.

2 The type of *Brotula marginalis* was found to have 24 pectoral rays, 13 scales above the lateral line and 36 scales below the lateral line. Due to the foreshortened tail other counts and proportional measurements were not taken on this specimen.

was justified in synonymizing all three nominal Hawaiian species with *multibarbata.* I can find no satisfactory differences on comparing Hawaiian material with specimens from Japan and the Philippines.

Geneiates ferruginosus was a manuscript name, properly referred by Day to *B. multibarbata.*

Brotula japonica was separated from *B. multibarbata,* also from Japan, by the higher ray counts. As counted by Steindachner the dorsal, anal, and caudal rays totalled 235 to 238, which is a proper number. Temminck and Schlegel obviously undercounted these rays as 186.

Brotula townsendi, based on a small specimen from Hawaii, was described as having only 2 rostral barbels, but the type figure shows 3 and Fowler has synonymized his species with *multibarbata.*

Brotula marginalis has also been referred by Fowler to the synonymy of *multibarbata.* The split caudal fin, low ray counts and proportionally large head indicated for *marginalis* are not valid characters, for they are all attributable to the fact that the holotype of *marginalis* (USNM 49694) obviously has a regenerated tail. It has no hypural plate and the unusually broad caudal arises directly from the caudal vertebrae. In characters not affected by a former loss of the tip of the tail, for instance in the vomerine dentition, in the color of the fins, and in the large size of the scales, it is quite typical of *multibarbata.* Fowler (1927: 32) reported another specimen from Honolulu with "abortive tail."

Brotula formosae, as indicated by the original description and figure, is wholly typical of *multibarbata.*

Brotula jayakari was described as having very few rays, particularly in the anal fin (70 to 82 rays), but again miscounts can be assumed; or, the counts may have been at the lower end of a variable range, for I have enumerated as few as 80 and 82.

Brotula mülleri as originally described appears to be quite typical of *B. multibarbata,* if we assume that Temminck and Schlegel undercounted the rays of the vertical fins.

Brotula palmietensis, like *B. maculata,* merely represents the juvenile phase of *B. multibarbata.* The very low ray counts were indicated as approximations, and were obviously in error.

It is possible that subspecies or races of *B. multibarbata* may prove separable when larger series are studied. Average differences in ray numbers are suggested by the data in Table III. The indicated differences in proportions, however, are largely or entirely attributable to individual and age variations. The specimens from the several regions are very different in size.

Following are data on the specimens, all in the United States National Museum, that were counted and measured for Table III: 115401, Hull Island reef; Leonard P. Schultz, July 12–15, 1939. 99250, Maitara Island, Dodinga Bay, Gillolo (Halmahera) Island, Dutch East Indies; "Albatross," November 26, 1909. 99206, Port San Pio V, Camiguin Island, Philippines; "Albatross," November 11, 1908. 99207, Pagapas Bay, Luzon, Philippines; "Albatross," February 20, 1909. 99241, Varadero Bay, Mindoro, Philippines; "Albatross," July 23, 1908. 99205, Port Galera, Mindoro, Philippines; "Albatross," June 9, 1908. 49694, Honolulu, Hawaii; holotype of *Brotula marginalis.* 126702, Honolulu, Hawaii; E. L. Berndt. 55507 (3 specimens), Honolulu, Hawaii; Jordan and Evermann. 55088 (3 specimens), Honolulu,

Hawaii; "Albatross." 22525, Sagami, Japan; Japanese Government. 75910 (2 specimens), supposedly Japan; Jouy.

As here delimited the range of *B. multibarbata* is very extensive, but the Indo-Pacific marine region which it covers has a large measure of faunal integrity and many other fishes have a very similar distribution. The records gleaned from the literature indicate that the species probably ranges continuously along all the shores of the Indian Ocean and throughout Indonesia, southern Japan, and Oceania.

B. multibarbata may occur in somewhat shallower water than do the two American forms. The young type of *B. palmietensis* was taken in a South African rock pool, and the young specimen reported by Schultz from Hull Island as *B. mulleri* was poisoned on the top of a shallow coral reef. Kaup's half-grown specimen from the Red Sea was taken with a hook on the slope of a coral reef. The occurrence of the species in markets also suggests a very shallow habitat. The sensory barbels (Satô, 1937: 274, 276) predicate nocturnal habits.

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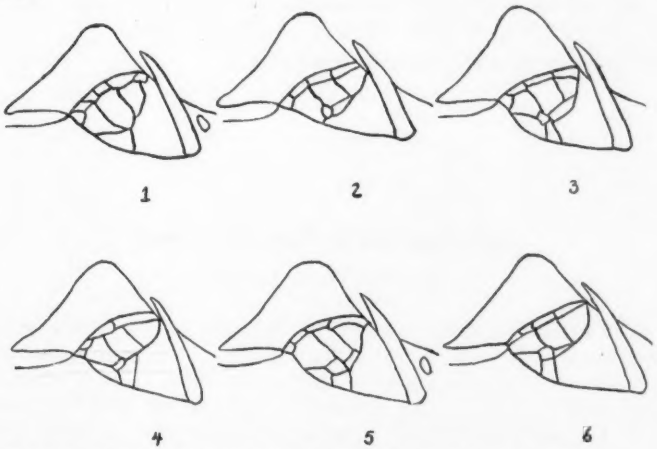
Variations in the Anatomy of the Dorsal Fins of *Squalus acanthias*

By Paul Benzer

DETAILED studies of the unpaired fins of the elasmobranchs were reported by Mivart (1879). Since then, his work has been supplemented by Balfour (1881), Daniel (1934), and White (1937). These workers gave no indication that the structure of the unpaired fins is variable in its anatomy, although a variability in the structure of the paired fins is mentioned by White (1937).

The notes reported here were compiled after it had been noticed, in several specimens, that there was considerable variation in the dorsal fin structures of *Squalus acanthias*. The material was all studied in gross dissections.



Figs. 1–6. Variations in anterior dorsal fin cartilages of *Squalus acanthias*.

The skeleton of one of the anterior azygos dorsal fins consists of three superimposed longitudinal series of adjacent cartilages, posterior to a sharp spine which the fin bears at its anterior end (Fig. 1). The basal cartilages consist of the cartilaginous base of the spine, of a large supporting sheet of cartilage, and a small triangular piece at its posterior end making them three in number. The median cartilages consist of three large triangular cartilages resting posteriorly on the basals. The distal cartilages are the six small ones of nearly equal size, which rest on the median cartilages and to which the actinotrichia, or body of the fin, is attached. This described fin is not to be considered a typical fin.

Examination of other fins of the same species shows a variation in the size, shape, and number of each of the cartilages found in the above specimen (Figs. 2, 3, 4, 5, 6). In each recorded case, segmentation has occurred differently, so that cartilages of unknown origin may be found located be-

tween the basal and median cartilages. In two specimens a small oblong piece of cartilage was found imbedded in the connective tissues immediately anterior to the base of the spine (Figs. 1 and 5).

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Superfetation in Poeciliid Fishes [1]

By Nevin S. Scrimshaw

SUPERFETATION, the occurrence of more than one stage of developing embryos in the same animal at the same time, is well recognized in the Poeciliidae, a viviparous family of cyprinodont fishes. The occurrence of superfetation in a number of additional species of this family is reported below. The past records consist of evidence from dissection of gravid females and suggestive reports of very short intervals between broods of young.

Seal (1911) reported broods of four to sixteen embryos produced by large specimens of *Heterandria formosa* at intervals of four to nine days. Snyder (1915) dissected specimens of *Poecilia* (now *Poeciliopsis*) *occidentalis* which contained more than one brood of embryos. Henn (1916) found two broods of developing embryos in *Pseudopoecilia fria* and *Diphyacantha chacoensis*. Stoye (1935) found the brood interval for *Poecilistes pleurosphilus* to be ten to twelve days. He also reported that *Priapella bonita, Phalloptychus januarius* and *Micropoecilia branneri* resemble *Heterandria formosa* in having young a few at a time at intervals of a few days. Turner (1940) reviewed the occurrence of superfetation in the cyprinodont fishes and discussed many of the factors involved. He reports for the first time the occurrence of this condition in a number of species of the Poeciliidae, some of them

1 Field work on Panama species was aided by a grant from the Penrose Fund of the American Philosophical Society. Laboratory studies were conducted in the Harvard Biological Laboratories as part of a doctorate research.

undescribed (Table I). In an earlier paper (1937) Turner gave an excellent account of the distribution and degree of viviparity in this family.

The initial reports of superfetation in species of poeciliid fishes are summarized in Table I. Those listed from brood records alone are indicated.

TABLE I

SUPERFETATION IN POECILIID FISHES

Species	First Report
Heterandria formosa	Seal (1911)
Poeciliopsis occidentalis	Snyder (1915)
Pseudopoecilia fria	Henn (1916)
Diphyacantha chacoensis	Henn (1916)
*Priapella bonita**	Stoye (1935)
*Phalloptychus januarius**	Stoye (1935)
*Micropoecilia branneri**	Stoye (1935)
*Poecilistes pleurospilus**	Stoye (1935)
Poeciliopsis infans	Turner (1937)
Poeciliopsis lutzi	Turner (1940)
Poecilistes A, B and C (Undescribed species from Mexico)	Turner (1940)
Poeciliopsis balsas	Turner 1940)
Poeciliopsis fasciata	Turner (1940)
Poeciliopsis A (Undescribed species from Mexico)	Turner (1940)
Flexipenis vitta	Turner (1940)
Aulophallus retropinna	Turner (1940)
Aulophallus elongatus	Turner (1940)

* Brood records only.

The species in which I have found superfetation by dissection and study of the gravid ovaries are listed in Table II along with other species examined. Ten are listed in this category for the first time. Of these *Lebistes reticulatus, Brachyrhaphis episcopi, cascajalensis, Gambusia noblis noblis, G. affinis holbrooki, G. dovii, Quintana atrizona* and *Mollienisia sphenops* do not regularly show superfetation. The younger broods are usually sparse in number and perhaps reabsorbed. All of the reports except three are for fishes reproducing in their natural tropical or subtropical habitat. The specimens of *Lebistes reticulatus* and *Poecilistes pleurospilus* represent laboratory stock under the stimulus of constant artificial light. Superfetation was not seen in *Lebistes* stock exposed only to natural light. The specimens of *Heterandria formosa* represent many specimens just received from Florida as well as laboratory stock kept under a wide variety of experimental conditions.

The effect of light in stimulating the reproductive activity of fishes is known (Rowan, 1926; Hoover and Hubbard, 1937; Turner, 1937). Under constant artificial light I have observed the brood interval in *Lebistes* to fall as low as 21 days as compared with the usual interval of 30 days or more. It was in this group that examples of superfetation were found. With other factors held constant, I have found *Heterandria* similarly sensitive to light, showing in northern latitudes a low degree of superfetation in fall and winter and a much higher degree in the spring and summer.

Hubbs (1944) has kept hundreds of brood records and counted the eggs or embryos of hundreds of preserved specimens of *Mollienisia sphenops* without ever noting *normal* embryos much smaller than the run.[2] Occasionally an *abnormal* runt or two was present but no true superfetation. My own records of this species taken from Gatun Lake, Panama, and studied while the embryos were still alive include several clear cut cases of apparently functional superfetation. For example female 7/4/40A, 5.8 cm. standard length, showed 22 embryos with optic cup well developed, eye pigment appearing and heart beating vigorously. This female also contained 20 embryos with an obvious primitive streak, a blastodisc extending over two-thirds of the yolk and a blastopore sharply outlined.

TABLE II

SUPERFETATION IN POECILIID FISHES AS DETERMINED BY DISSECTION OF FEMALES

Species	No. gravid females	No. cases of superfetation	Maximum no. of broods
Allogambusia tridentiger	14	14	3
Allophalus kidderi	7	0	1
Aulophallus elongatus	9	9	5
Belonesox belizanus	3	0	1
Brachyrhaphis cascajalensis	27	5	2
Brachyrhaphis episcopi	24	2	2
Brachyrhaphis terrabensis	4	0	1
Darienichthyes dariensis	7	0	1
Dextripenis evides	8	8	3
Gambusia dovii	16	1	2
Gambusia affinis holbrooki	13	4	2
Gambusia nobilis nobilis	7	1	2
Heterandria formosa	123	116	8
Lebistes reticulatus (lt.)	15	3	2
Mollienisia sphenops	15	5	2
Mollienisia velifera	2	0	1
Poecilia vivipara	3	0	1
Poeciliopsis infans	7	3	2
Poeciliopsis occidentalis	8	7	2
Poecilistes pleurospilus(lt.)	5	4	3
Poecilistes pleurospilus	6	5	2
Pseudoxiphophorus bimaculatus	5	0	1
Quintana atrizona	2	1 (?)	2 (?)

These observations suggest that superfetation in *Molliensia* will occur only under very favorable environmental conditions and almost never under ordinary laboratory treatment. Similarly most of the fish for which superfetation is listed as a rare occurrence will not show this condition except in a favorable natural environment or under special laboratory conditions of constant illumination and unlimited food. It is also true that abnormal embryos or runts may be difficult at times to distinguish from embryos fertilized later than those of the main brood. These do not represent superfetation but merely something genetically or environmentally wrong with the individual fish. I have tried to exclude any such doubtful cases from Table II.

2 Hubbs (*in litt.*, June, 1944) has since reported dissecting several females which clearly showed broods of two different ages. It is probably significant that these were found in the late spring when the hours of daylight were at a maximum.

Nearly every poeciliid species which has been examined in significant numbers shows at least occasional superfetation. However, it is likely that in many of these occasional cases the youngest broods become atretic and are reabsorbed. In fact many of the species reported probably show a tendency toward superfetation without making functional use of it in their normal reproductive cycles. *Gambusia, Brachyrhaphis, Lebistes* and probably *Mollienisia* are examples of this type. Other species such as those of *Poeciliopsis* and *Poecilistes* represent intermediate stages in the development of a high degree of superfetation.

As Turner (1937) noted, in those species which have attained the highest degree of superfetation, namely *Heterandria formosa* and *Aulophallus elongatus,* the fertilized egg is minute and the amount of stored nutriment is insignificant. The fertilized eggs of *Heterandria* averaged only 0.017 milligrams dry weight while the young at parturition average 0.85 milligrams. The contrast is even more marked in *Aulophallus elongatus* for which the initial dry weight is 0.02 milligrams and the final weight about 12.5 milligrams.[3] In these forms the mother must supply nearly all the nourishment to the embryo as it develops.

The parallel development of true viviparity and superfetation warrants further study. In this connection it must be noted that no poeciliid fish in which the fertilized egg contains sufficient nourishment for development (that is, no ovoviviparous species) has developed pronounced superfetation. This seems true despite the fact that its occurrence in the members of the family studied suggest superfetation to be at least potentially present in all of them.

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School of Medicine, University of Rochester, Rochester, New York.

[3] Original data obtained from 122 gravid females of *Heterandria* and 10 of *Aulophallus*.

Ichthyological Notes

NOTE ON A CONTROLLED FEEDING TECHNIQUE IN NUTRITION STUDIES IN TROUT.—In the course of researches on the control of fish diseases and on nutrition problems of trout, it became evident that further data on basic nutrition requirements of these fish would be necessary. Obviously, nutrition studies of this type require the use of artificial diets, and the problem of feeding them to aquatic species is apparent. The principal disadvantages of ad libitum feeding are the loss of elements by solution, the uncontrolled palatability and individual intake of such diets. Consequently, it became desirous to develop a technique of feeding in which the individual intake of food by fish would be controlled and also to make certain that the nature of the diet is unchanged.

Efforts were centered on the development of a technique which would permit the routine feeding of fish in such a manner that the quantity and quality of food taken by each fish would be controlled. Several methods were tried. First, oral and stomach tube feeding was attempted and found unsatisfactory because of loss of food by regurgitation. Second, the diet was compressed into tablet form and fed to the fish. The third technique attempted was that of packing the food into a gelatine capsule and force feeding it to the fish. This method is the most satisfactory since, as has recently been learned, gelatine is necessary for the normal growth of trout receiving a mixed natural type of diet.[1]

The procedure is as follows:

The first step is to select the size of capsule for the size of fish. Most of the experiments are initiated with trout that are approximately 20 grams in weight; and the weight of food fed them is at an intake of 1.5 or 2 per cent of the average body weight. The sizes of capsules we have found most satisfactory are size 4 or 5 for a 10 gram trout, 2 or 3 for 20 gram trout and 00 to 0 for 40 gram trout. In feeding, the fish is firmly grasped with a moist hand about the head and body so that the gills are compressed and the head pointing upward. The fish is taken from the water and held just above its surface. A moistened capsule is then placed in the back of the mouth of the fish and gently forced through the esophagus by a polished glass rod whose end is concave.

Using this technique, rainbow trout have been maintained on a synthetic diet for more than four months during which they doubled their initial weight of 30 grams. They were capsule fed once daily. Mortality in these experiments ranged from 1 to 10 per cent per month. However, in experiments under way at the present time, no loss has been experiencd among 100 fish in over a month of feeding. The regurgitation of 3 or 4 capsules daily for 25 fish is considered normal. This appears to be a reaction of fish which had not completely digested the capsule fed the previous day. The loss of capsules by regurgitation can be more readily detected if colored capsules are used. Those colored pink are most easily seen under water in the tank.

In the preparation of the capsule, the weight of the capsule is included in the amount of diet which is to be fed. Each is packed individually and weighed. With some skill and practice, approximately 100 capsules can be filled per hour.—JOHN B. FIELD, ELMER F. HERMAN, C. A. ELVEHJEM, and EDWARD SCHNEBERGER, *Dept. of Biochemistry, University of Wisconsin* and *Wisconsin Conservation Department, Madison, Wisconsin.*

THE SHEDDING OF SELACHIAN TEETH AND ITS RELATION TO TOOTH REPLACEMENT IN FISHES AND REPTILES.—In the 1942 (1) number of COPEIA (pp. 42–44), Dr. C. M. Breder, Jr., reports extensive shedding of teeth by *Carcharias littoralis* (Mitchill), but he gives no evidence to show that these teeth are replaced by newly formed ones. It is possible that loss of teeth may be common where deep-sea fish are transferred to an artificial environment.

Illustrations of the abnormal teeth of selachians, which resemble normal teeth that have split in half through the pulp chamber, show no trace of the foramen which would

1 FIELD, JOHN B., ELMER F. HERMAN AND C. A. ELVEHJEM. 1944. Increased growth produced by gelatin in trout fed meatless diets. *Proc. Soc. Exp. Biol. and Med.* 55, 1944: 222.

disappear if the crack took place through the weakest portion of the tooth. Some examples even suggest that the tip of the exposed fractured surface has been broken.

Small teeth, such as sometimes occur among the foremost teeth of the slender-toothed sharks, would not be possible if the stouter hinder teeth were constantly replacing teeth shed from the anterior extremity of the tooth-bearing area. Furthermore, the teeth of the front part of the jaw are too overcrowded and huge to render succession possible here.

Among Batoidei, the hinder teeth are often considerably larger than the foremost ones, so that the presence of small, apparently worn teeth in front, like those found in the embryonic state where wear and tear are out of the question, militates against the conception of constant shedding and replacement, which would also be impossible in some selachians whose teeth never erupt.

We see a similar condition in the molluscan radula, where the teeth of the anterior extremity do not develop the sharp cusps seen further back, though constant wear and tear of the rows when they do come into use results in some thirty or more rows of blunted teeth in old individuals, in contrast to the few "blunted" rows of the front end of the embryonic radula.

Though selachian teeth have not the open pulp chamber of crocodiles, the open foramen of their teeth indicates that growth continues throughout life. Nevertheless, so far, no experimental proof seems to be available of the persistence of teeth, even among the large number of examples kept in captivity in aquaria.

Examination, both by dissection and by radiograph, of the jaw of *Crocodilus niloticus* Laurenti at various stages of development, fails to reveal more than one row of reserve teeth in many specimens. The size of teeth from most portions of the jaw is related to age, and blunting is present in both buried and exposed back teeth.

So deep is the idea of succession of teeth among fishes that I was once told by a professor of anatomy that the little hinder teeth of *Pagrus nasutus* moved forward to replace the large front ones that were shed, and a leading authority on South African fishes observed "Upwards, yes," even though dissection reveals the one series of replacing teeth below both large and small teeth.

It is probable that the little teeth of *Pagrus nasutus* serve to strengthen the hold of the gum, and that there is a function for the backwardly directed teeth of such fishes as *Hydrocyon* and *Schymnorhinus* which may also apply to the teeth of selachians buried under the gum and can serve far less purpose than those of the erect row.

But there is no sign of new tooth formation behind the constant number of rows of teeth in many fishes and selachians. As the possibility of vertical succession in selachians is absent, one is forced to the conclusion that there is no provision for replacing loss, the dentition being a complete entity, except for possible increase in number of teeth in each horizontal row.

The problem exists in a similar way in reptiles and surely an explanation is needed for the theory that even anchylosed teeth in the jaw of a snake can ever be shed and replaced. Here again the size of both solid teeth and fangs usually corresponds with the age of the snake, and the little loose hinder teeth remain soft and undeveloped.—F GORDON CAWSTON, *Britannia Buildings, West St., Durban, South Africa.*

NEW LOCALITY RECORDS OF THREE PACIFIC COAST FISHES FROM OREGON.—Fishermen at Yaquina Bay, Oregon, frequently bring the unusual fishes captured in their nets to the Oregon State College Oyster Laboratory for identification. During the past three years, three species known from California waters, but apparently not previously reported from Oregon, have been obtained in this manner. A bat stingray, *Aëtobatus californicus* (Gill), was taken on May 15, 1941, in a gill net by Kenneth Hunsaker. The stomach contents of this specimen contained the broken shells of the native oyster, *Ostrea lurida* Carp. Three leopard sharks, *Triakis semifasciatum* Girard, were caught on May 1, 1943, by Eugene Wright about 5 miles up the bay from ocean. A single specimen of the queenfish, *Seriphus politus* Ayres, was obtained in the bay by Mr. Wright off Yaquina on June 16, 1942. Several other fishermen stated that they had seen similar specimens of queenfishes in other years while fishing for bay smelt. The specimens of the bat stingray and the queenfish are in the collection of the Fish and Game Management Department, Oregon State College.—R. E. DIMICK, *Dept. of Fish and Game Management, School of Agriculture, Oregon State College, Corvallis, Oregon.*

A SIZE RECORD FOR THE WINTER FLOUNDER, *PSEUDOPLEURONECTES AMERICANUS*.—The Bingham Oceanographic Laboratory at Yale University recently received three large specimens of the winter flounder (*Pseudopleuronectes americanus* Walbaum) from Captain Ellery Thompson, of New London, Connecticut. These fish had been taken on March 12, 1944, about 5 miles due southwest of Block Island, Rhode Island, in a modified otter trawl at a depth of 22 fathoms.

The largest specimen was 56 centimeters (22 inches) in total length, 46.5 centimeters standard length, 31.5 centimeters across the widest part of the body and fins, and 2,649 grams (5.84 pounds) in weight. The fish was a female, approaching spawning. The left ovary weighed 417 grams, the right ovary 324 grams. Thus, together they constituted about 28% of the total weight. It is interesting to note that in the two smaller specimens also, the left ovary was considerably heavier than the right.

Examination of a sample of six scales from this large specimen indicated that it was a seven-year-old (in its eighth year). Six distinct annuli appeared on the scale, with a seventh annulus and a slight growth increment, typical of older fish, at the periphery. Study of the otoliths tended to confirm this age determination. The stomach was empty.

This specimen is larger than any previously recorded. The largest size records heretofore have been reported by Storer (1867, History of the Fishes of Massachusetts), 21 inches, and by Breder (1929, Field Book of the Marine Fishes of the Atlantic Coast), 20 inches.

The specimen was examined carefully lest it prove to be a lemon sole (*Pseudopleuronectes dignabilis* Kendall) rather than a winter flounder. Fin ray counts and dentition showed it to be the latter. However, in a comparison of other taxonomic characters of the specimen with those given by Kendall (1910, Bull. U. S. Bur. Fish. 30) for *P. dignabilis*, and by Norman (1934, Monograph of the Flatfishes) for *P. americanus*, the specimen was intermediate between the two types in several respects. It will be noted that the ranges of the various characters overlap in the two species, and that those of the specimen here reported were, in most cases, near one end of the ranges given for *P. americanus*. This is shown in the following table.

	B.O.L. Specimen 22″	(Norman) *P. americanus* 15″	(Kendall) *P. dignabilis* + 20″
Length			
In st'd length			
Head	4.4	3.6 — 4.6	4.26 — 4.87
Depth	2.0	2.0 — 2.6	2.08 — 2.36
In head			
Eye	6.0	4.25 — 6.0	5.70 — 6.58
Mandible	abt. 3	abt. 3	2.60 — 3.14
Longest dorsal ray	2.2		1.70 — 2.00
Longest anal ray	2.2		1.70 — 2.00
Pectoral	1.8	1.6 — 2.0	1.60 — 1.94
Snout	5.5		4.86 — 5.00
Gill rakers	4 + 8	3 — 4 + 7 — 8	4 + 8
Dorsal rays	66	59 — 71	68 — 73
Anal rays	49	47 — 54	50 — 54
Pectoral rays	10	10 — 11	
Dentition	2 + 15	0 — 2 + 10 — 15	2 + 17
	2 + 17	0 — 2 + 10 — 17	0 + 17

JAMES E. MORROW, JR., *Osborn Zoological Laboratory and Bingham Oceanographic Laboratory, Yale University, New Haven, Connecticut.*

Herpetological Notes

GONATODES FUSCUS IN MEXICO.—Rich in many groups of reptiles, Mexico is relatively poor in geckos, of which only seven genera have been reported. Two of the genera are immigrants from the Old World (*Hemidactylus, Peropus*), and one (*Aristelliger*) is probably a waif from the West Indies. *Sphaerodactylus, Phyllodactylus, Thecadactylus* and *Coleonyx* are almost unquestionably native.

A recent collection secured through Mr. Thomas MacDougall contains a single specimen of *Gonatodes fuscus* (Hallowell) from Huixtla, Chiapas, and thus adds another genus to the Mexican list. The specimen was found in a hotel on April 22, 1943, and is now incorporated in the EHT-HMS collection. Several others were observed but not captured. A comparison of the specimen, a young female measuring 24.3 mm. snout to vent, with a series of other specimens of *Gonatodes fuscus* from Nicaragua and El Salvador, furnished through the courtesy of Dr. Norman Hartweg of the Museum of Zoology of the University of Michigan, reveals no significant peculiarity in the Mexican specimen. Like other females of the species, it has a pair of dark spots on either side of the middorsal line on the nape; a series of similar, closely placed spots forming a transverse band on the back behind the shoulders; and on the remainder of the back a series of 6 transverse rows of spots progressively decreasing in distinctness and closer to each other posteriorly. The tail has narrow, indistinct light bands, and the tip is dark. Behind each transverse row of dark spots on the back is a narrow band of light dots; that on the nape is continuous with a narrow, vertical light line in front of the shoulder. The scales on the back and top of head are, as in others, small, uniform, and overlapping; the belly scales are larger and flat. The supralabials are 5 to below the middle of the eye, the infralabials 3 to the same point. The skin about the eyes covers a considerable portion of the eyeball. The mental is very large, and is bordered posteriorly by 3 small postmentals. There are no femoral or preanal pores. The lamellae under the basal phalanges are distinctly enlarged, contrary to some descriptions of the species, but exactly as in the comparative material. On the 3rd toe, which is provided with more large lamellae than any other digit, there are 5 lamellae under the basal phalanx, the largest (3rd) fully as long as 3 lamellae on any of the other phalanges of that digit, and only about a third longer than wide. Although the exact number of expanded lamellae varies amongst the specimens examined, the relative proportions of the basal and distal lamellae remain about the same in all. The basal lamellae of the 4th and 5th toes are less distinctly enlarged, although more numerous than on the 3rd toe.

Since the species is one that occurs abundantly about human habitations, there is a strong possibility that it has reached Mexico fortuitously by aid of man. Since it is known from El Salvador, however, and is perhaps native there, its occurrence in Chiapas is to be expected, if natural biotic provinces are a reliable indicator.—Hobart M. Smith, *University of Rochester, Rochester, New York.*

OBSERVATIONS ON *HYLA EVITTATA.*—I have been rather interested in the habits of *Hyla evittata* Miller as observed on our farm, which joins Pohick Bay, a tributary of the Potomac River, some 21 miles south of Washington. Our house is approximately two-fifths of a mile from the water at an elevation of 155 feet.

In the late summer when the young hylas have reached a little more than half their adult size they leave the lily pads and bonnets of the bay and move inland. At this time the frogs come to our upland level, where we find them particularly partial to okra plants. I have found as many as six attached to the stems of a short row of this vegetable; they blend beautifully into the okra color scheme.

All the specimens caught on our place are *evittata;* that is, they lack the band characteristic of *H. cinerea.* On the north side of the Potomac River at Foxes Ferry I have found the striped form predominant and the *evittata* color scheme only slightly represented.—Paul Bartsch, *U. S. National Museum, Washington, D. C.*

NOTES ON *AMPHISBAENA FULIGINOSA*.—A specimen of *Amphisbaena fuliginosa* Linnaeus was caught alive about June 25, 1943, at Val de Caes Air Field, some 7 or 8 miles north of the city of Belem, State of Para, Brazil. It was found by a native on the damp loamy soil of a new road at the time under process of improvement by road grader. This was at the partly cleared edge of a jungle near Army officers barracks. I kept the lizard alive until August 29 or 30, when it died in a bag while traveling by train through the southwestern United States.

The length over-all was 13 inches. The scales were smooth and glossy. The skin was loose, with more or less of a lateral fold on each side depending on how well fed it was. The body form was cylindrical when well fed, at other times somewhat flattened. The head and tail were blunt and rounded. The coloration was white with black spots. No odorous secretion for defense was noted when the lizard was handled.

The tongue is rather broad and short. The forks do not seem very long when the tongue is being used to find food.

It fed only on earthworms. Other live food (insects, millipedes, and a frog) was ignored. After grasping a worm the lizard pulled its head back, and from side to side, continuing this motion quickly from time to time—perhaps a useful reaction to free a large worm from the soil. The food was found only by the senses of smell and touch. When it smelled food it nosed around until its nose touched the worm, which was then grasped and swallowed. It drank water when placed in a basin.

The amphisbaena shed its skin once while in captivity but only accomplished the first stages without help. Its behavior in the process of shedding its skin was very snake-like. When I observed that the skin was nearly ready to shed I let the specimen swim in a basin of water for a few minutes and then put it back in its cloth bag after soaking the bag in water. The following day when the bag was opened the lizard was seen to have started shedding. The head and nearly half the body was already cleanly shed and the old skin was turned back and matted thickly over the middle of the body. I lifted the specimen out of the bag and assisted the rest of the process by hand. The skin was in one piece up to that point, but I tore the matted part off to make the rest of the shedding easier. The lizard crawled through my fingers, rubbing the old skin back just as a snake does, and using the same technique of contracting the body muscles behind the line of skin separation and expanding the body forward of the separation, the whole action being a slow wave-like motion. I believe that under natural circumstances the skin would have been shed entirely in one piece.

The lizard was rather slow moving and not much disturbed by handling. It tried to burrow into or under anything that it was placed on, and seemed quite blind, although the vestigial eyes (small round black spots) may be able to distinguish light and darkness.

It was able to swim on the surface as well as under water, but attempted to escape from the water when it was placed in it. When it crawled through my hands the lizard's ribs and body muscles could be felt and seen to ripple the scales in the wave-like manner of snakes. Progress was largely due to the action of ribs and ventral scales, assisted by sinuous movement of the head, neck, and body. When the lizard was placed on a smooth floor of cement, it could crawl easily by means of rib and ventral scale action; but it was quick to utilize any object or irregularity of surface it might touch by pushing out a lateral loop for better traction. Its rate of movement was slow at best, and since it could not see danger it did not try to escape by flight. When given opportunity to escape it proceeded slowly to crawl off nosing about as it went for a place to burrow or something to crawl under.—R. B. FINDLEY, JR., *Lt. (j.g.), U.S.N.R., San Diego, California.*

SOME EUROPEAN SNAKES INTRODUCED IN BALED CORK-BARK.—During the early spring months, several specimens of snakes were sent to the Reading Museum by the caretaker of a stock-pile of baled cork-bark, received during the winter, supposedly from Portugal. This stock-pile is located within the city limits of Reading. Since that time reports have arrived of a number of snakes having been killed at other stockpiles in various localities in the county; due to travel difficulties, no further specimens have been obtained. The three originally received are as follows:

The viperine water snake, *Natrix viperina* (Latreille), rather widespread in Italy, France, Spain, and Portugal. One example 41.5 cm. long, the other 18.5 cm., both captured March 26, 1943.

The Montpellier snake, a rear-fanged (mildly poisonous) species, *Malpolon monspessulana* (Hermann), found along the borders of the Mediterranean Sea and eastward to Iran. A single specimen, 105 cm. in length, was taken on April 2, 1943.

The writer wishes to thank Dr. Edward H. Taylor, of the University of Kansas, for determining the specimens and supplying the distributional notes.—Lawrence S. Dillon, *Reading Public Museum and Art Gallery, Reading, Pennsylvania.*

NOTES ON SOME REPTILES AND AMPHIBIANS FROM CEIBA, HONDURAS.—On a return journey from Jamaica, B.W.I., in August, 1941, a twenty-four hour stopover in the port of Ceiba, Honduras, afforded an opportunity for collecting at that locality. The town of Ceiba is a small banana port lying on the Caribbean coast of Honduras about 60 miles east of Tela and about the same distance west of Trujillo. The coastal plain at this point is rather low and swampy, but high mountains rise just behind the town. Our collections were made on the day and evening of April 25, 1941, and during the early hours of April 26. Most of the specimens were taken in fields and streams at the western edge of the town. We were favored in our search for amphibians by the fact that a light rain fell intermittently through the night. The author is indebted to Dr. James N. Dent for aid in the collecting.

All of the species represented in the present collection, except *Hylella picta,* have been recorded from Honduras by Dunn and Emlen (1932, Proc. Acad. Nat. Sci. Phila., 84: 21-32). The collection has been deposited in the United States National Museum except for two specimens of *Hyla underwoodi* which were presented to the Museum of Zoology of the University of Michigan. An annotated list follows:

Bufo marinus Linnaeus.—Two specimens from a temporary pool in an open field. Body length: 126 and 118 mm. Colors in life: back olive with splotches of very light tan, sides dusky yellow, belly white. We did not hear the call of this toad in Honduras although the species had been quite vociferous in Jamaica when we left there a few nights before.

Bufo valliceps Wiegmann.—Four adults and one juvenile from temporary pools in an open field. The adults range in length from 58 to 63 mm. Colors in life: back brown, black interocular bar, well-defined inverted V-shaped mark on scapular region, sides tan, belly cream with scattered dark spots. Some specimens have a narrow middorsal light stripe. All of the adults are males which, when taken, were delivering the call, a loud rolling trill.

Hyla baudinii Duméril and Bibron.—Three specimens, which when taken were calling from bushes at a height of 4 to 6 feet. The call was recorded in our field notes as "wonk-wonk-wonk" given with a decided, nasal sound and resembling the noise of an old-fashioned rubber-bulb auto horn. Dunn and Emlen refer to the call as "a low, deep, resonant 'beep, beep' repeated six or seven times." These specimens exhibited the following colors in life: back tan, shading to yellow on the sides and in the groin; black line above tympanum broadening to a black patch above the fore limb; eyes tan above the pupil and brown below; irregular dark brown patches on back; dark brown cross bars on upper surfaces of limbs. All three specimens measure 56 mm. All have prominent paired vocal pouches below the angles of the jaws.

Hyla staufferi Cope.—One specimen. I am indebted to Mrs. Helen T. Gaige for identification of this specimen as well as those representing *Hyla underwoodi* and *Hylella picta.* This animal was taken from tall grass at the edge of a shallow pool. Length, 24 mm. Colors in life: back brown with irregularly distributed dark brown spots, dark brown line from eye along side of body to near groin, belly white. This species is recorded as *Hyla culex* by Dunn and Emlen.

Hyla underwoodi Boulenger.—Ten specimens, 8 males and 2 females, from low grasses at the edges of temporary ponds in open fields. The call may be transliterated as "kreks-ex-ex-ex." Most of the individuals are about 24 mm. in length; the largest, a female, is 29 mm. Colors in life: back light tan to yellow, belly lemon yellow, dark stripe above tympanum and along side of body, dark interocular bars and irregularly anastomosing dark lines present on the dorsal sides of all specimens but varying greatly in prominence in different individuals.

Hyla venulosa (Laurenti).—Two specimens which, when taken, were calling from bushes about 5 feet from the ground. The call is a creaking "kraack," a sound like that

made by drawing the finger over an inflated toy balloon. Body lengths: 60 and 64 mm. Colors in life: back uniform dark olive, belly yellow passing into greenish at the posterior end. The thumbs of these animals bear well-developed pads. The vocal sacs project as ear-like processes behind the tympani. When captured, both specimens emitted copious amounts of their white rubbery cutaneous secretion.

Hylella picta Günther.—One specimen, from low grass at the edge of a shallow pool. Length, 20 mm. Colors in life: back reddish-brown with scattered round spots of deeper red-brown, brown line with a light upper border extending from nostril through eye and halfway to hind-limb, ventral side white.

Rana pipiens Schreber.—Two specimens from a shallow pool. Both are females measuring 93 mm. in length. In life the two differed markedly in color and pattern. One had a gray ground color with a double row of large dark brown blotches between the dorso-lateral folds while the other was uniform olive-brown with no dark blotches and with a bright green tinge on the head.

Anolis sallaei Günther.—One specimen, from a bush at night. Snout to vent, 33 mm.; tail, 80 mm. Colors in life: back tan with scattered small brown blotches, narrow brown interocular bar, belly yellow, dewlap burnt ochre with a central spot of navy blue.

Basiliscus vittatus Wiegmann.—One adult and two juveniles taken from low branches of trees at night. Measurements of the adult are: snout to vent, 115 mm.; tail, 354 mm. Colors in life: ground color of body olive-gray with cross bars of brown, lips and chin lemon yellow, eyes olive-green, top of head and crest olive-gray, yellow stripe behind tympanum changing to olive at level of fore-limb, yellow stripe from angle of mouth to above fore-limb, dewlap olive flecked with yellow, tail light gray with brown cross bars.

Cnemidophorus lemniscatus lemniscatus (Linnaeus).—One specimen, taken in a cocoanut grove near the beach west of Ceiba. Many of these active lizards were seen here although only one was captured. When disturbed this animal runs for a short distance then turns to face its pursuer and, standing on three legs, holds one front leg off the ground and shakes it rapidly in what appears to be an involuntary convulsive movement. If one continues to approach, the whole performance is repeated. Even when the animal hides beneath a fallen leaf or a pile of debris its presence is frequently revealed by this movement. This habit has been recorded by Stejneger (1901, Proc. U.S. Nat. Mus., 24: 184). The specimen collected was light brown with the longitudinal stripes yellow and the belly greenish blue. Many specimens seen, however, had bright patches of green on the sides of the head and body.—W. Gardner Lynn, *Department of Biology, The Catholic University of America, Washington, D.C.*

NOTES ON THE EGG LAYING OF A BLACK CHICKEN SNAKE.—A five-foot female black chicken snake, *Elaphe obsoleta obsoleta* Say, from Oldham County, Kentucky, was kept alive in my collection from August 2, 1938, to October 28, 1943. For nearly three years she was the sole occupant of the cage, but on May 16, 1941, a male of the same species from Jefferson County, Kentucky, was placed with her. The male measured 4 feet 2 inches in length. Both of the adult snakes became tame at once and always fed readily, showing little preference between live or dead food.

The cage in which the snakes are kept is without accessories, 2 feet long, 1½ feet wide, and 1½ feet high. The front is glass, the top and upper part of the back are screen while the bottom, ends, and lower part of the back are solid wood. The internal fixtures are an enamel water pan and a wooden box with a small opening in one side to form a dark retreat. During warm weather the cage is kept outdoors, protected from rain by a shelter.

A few weeks after placing the male in the cage, a mating was attempted, but the female was rather violent in her objections and thrashed her body around the small cage, considerably hindering the male. As he persisted in his attempts the pair was finally separated to keep them from injuring themselves. After several days they were reunited, but there was no recurrence of the attempted mating.

A mating took place between these specimens in the spring of 1942, but unfortunately was not observed. A clutch of eight eggs was laid July 16, 1942. Seven of the eggs were placed in a covered container on a layer of moist sterilized sand and covered with a layer of sphagnum moss. These eggs began to hatch on September 29, and by October 3

all but one had hatched. The longest time required for incubation was 109 days. The eggs were kept in the basement where the temperature remained near 65° F, or lower, which may explain the long period of incubation.

The young snakes were aggressive even immediately after leaving the egg, and vibrated their tails and struck like a full grown specimen. They steadily refused meal worms, newly hatched fence swifts, and tree frogs (*Hyla versicolor*).

On June 2, 1943, my father, who is caring for the snakes for me while I am in the army, wrote me that a mating took place on that date. A clutch of ten eggs was laid on July 20, 1943. The eggs averaged 45.5 mm. by 21.6 mm. Nine eggs were incubated and six hatched on September 20. These specimens measured about 351 mm. long and 7 mm. in diameter, and resembled those of the year before in habits and appearance. They refused baby mice.—KEITH V. SLACK, *Kirtland Field, Albuquerque, New Mexico.*

NOTES ON THE COURTSHIP OF A FLORIDA TERRAPIN.—In the aquatic turtles of the genera *Chrysemys* and *Pseudemys* the toenails of the forefeet of males are extremely elongate, and since it has long been believed that this character is in some way connected with sexual activity, the species of these genera have been thought to have similar courtship habits. While courtship has often been observed among captive individuals, observations in nature are few. The following comments may be gleaned from the literature.

Pycraft (1914, Courtship of Animals) witnessed courtship of *Chrysemys picta* in the Zoological Gardens in London. The male swam around and opposed the path of the female, and then "commenced to apply the bastinado to her head."

Taylor (1933, Univ. Kansas Sci. Bull., 21: 269–271) observed the courtship of *Pseudemys scripta troostii* and *Chrysemys picta bellii*, among captive individuals, and these forms exhibited essentially the same pattern of behavior. The male would swim faster than the female, and once having overtaken her, would whirl around backwards just in front of her, "and as the female approached, he would push himself forward, with the palms turned outward, the claws and fingers straightened, and vibrate them rapidly against the chin and lores of the swimming female." Conant (1938, Amer. Midl. Nat., 20: 153–154) witnessed similar behavior among captive *Pseudemys scripta troostii*.

Cahn (1937, Univ. Ill. Bull., 35: 135) in reference to *Chrysemys picta marginata*, states that the turtles become increasingly active during the breeding season, often travelling in pairs, with the male following the female; two or even more males may be seen pursuing a single female and the female is always in the lead. One male was seen to catch up with a female; he climbed onto her carapace and seemed to be clawing at her head and neck, but she evaded him, and he again took up the pursuit. Another male was seen to catch up with a female and apparently to claw at her head and neck from above.

During 1941 and 1942 I spent some time observing the habits of turtles in Blue Springs, a large calcareous spring about 150 yards from the Santa Fe River in Gilchrist Co., Florida. The water in the spring and in the run connecting it with the river is extremely clear, making possible the use of water-goggles for underwater observation, a technique to be described elsewhere.

On January 21, 1942, I noticed unusual activity among the *Pseudemys* population, which consisted almost entirely of *P. floridana suwanniensis*. The females were swimming slowly, usually about 3 or 4 feet below the surface of the water, each with a smaller male following her. This procedure was noticed in many separate cases. The male would then swim up and over the female, until anteriorly they were about even. The female would swim slowly with her head and neck extended, and the male would then thrust his head forward and arch it downward until it was only about a half inch from that of the female. In swimming in this position his forefeet were held quite close together, almost touching the neck of the female. The pair would swim in this manner for variable distances, in one instance as much as 25 yards. The turtles seemed to be quite oblivious to their surroundings, and certainly paid no attention to me. During this time the tail of the male was extended straight downward and was curved forward at the end. Males were often seen swimming alone, presumably hunting females, and their tails had this characteristic downward extension and hook, making recognition even at a distance an easy matter. Frequently, after a period of swimming about slowly in the characteristic

attitude of a pair, a male would slip backward on the carapace of his partner, his tail curving under the posterior end of her carapace. In this position they usually settled slowly to the bottom, where if undisturbed, they remained longer than I had the patience to watch them. If caught, no actual copulation could be detected. This pattern of behavior was observed repeatedly with no appreciable variation.

The observations made at Blue Springs confirmed previous ones at Rainbow Run, Marion Co., Florida. It had been frequently noted that when a male seen on the bottom in vegetation was caught, a female would be found under it, although no copulatory connection was ever noted. After the observations at Blue Springs, I determined to see if courtship could be observed at Rainbow Run, since I had a better idea of what type of behavior to expect. I witnessed numerous examples of the same type of courtship on the next visit to Rainbow Run.

I am unable to correlate my observations with those recorded in the literature, except for those of Cahn. Most of the recorded observations agree that the male swims backward in front of the female and strokes her face with his long forenails. This mesmeristic act must certainly be followed by considerable maneuvering before actual copulation occurs, since the male, swimming backward in front of the female, is in a position in no way calculated to lead to fertile intercourse. I feel certain that this type of courtship is not practiced by Florida *Pseudemys*, for I have spent several thousand hours in observing turtles under the most favorable circumstances, and nothing of this sort was ever witnessed. The behavior observed among courting individuals of *P. f. suwanniensis*, although less spectacular than the lashing with the long nails described by other authors, seems a more natural prelude to copulation.—Lewis J. Marchand, *Dept. of Biology, University of Florida, Gainesville, Florida.*

ELEUTHERODACTYLUS RICORDII AT JACKSONVILLE, FLORIDA.—During the past few years several residents of Jacksonville have told me of a small brown frog commonly found there in vacant lots, gardens and flower beds. Its reported size, color and habitat suggested *Eleutherodactylus ricordii* (Duméril and Bibron) but I was unable to obtain specimens until Mrs. A. N. Dow found eight "small white eggs" in a flower pot in her yard and kept them until they hatched. The baby frogs were sent to me for identification, and proved to be *ricordii*.

The eight individuals vary in length from 4.5 to 5.5 mm. From sub-adults from Gainesville they differ only in having the tympanum slightly less distinct, the head relatively broader, and the vomerine teeth less well developed. The eight specimens are now catalogued as number 22557 in the collection of the Carnegie Museum.

Mrs. Dow informs me that the locality where these frogs were found is in a residential section about 3 miles from the business center of the city. She found the eggs in a flower pot which had been left undisturbed in a flower bed in the yard for several months. The eggs were deposited on the surface of the soil and when Mrs. Dow first discovered them she placed them and the accompanying soil in a jar where they remained until they hatched about a week later. She sent them to me on August 2, 1943, when the frogs were "three or four days old." In answer to my query about adults, she stated that she had not noticed them about but that a neighbor had seen frogs of this description behind the houses in the neighborhood.

While these frogs are often accidentally transported in shipments made by nurseries and greenhouses, the fact that the eggs were found in a place which had not been disturbed since early spring seems sufficient evidence that the species is established in the Jacksonville region.

Since *Eleutherodactylus ricordii* was first reported in southern Florida by Cope (Bull. U. S. Nat. Mus., (1), 1875: 31) it has steadily extended its range northward. Carr (Univ. Fla. Biol. Sci. Ser., III, (1), 1940: 63) gives its range as continuous in south Florida northward to the region of Melbourne on the east coast and Clearwater on the west coast with a separate population at Gainesville. I do not know how rapidly the southern Florida population is spreading northward, but the Gainesville population is certainly expanding steadily and the species is now quite common several miles from the city in localities where it was not known to occur a few years ago.—Coleman J. Goin, *University of Florida, Gainesville, Florida.*

REVIEWS AND COMMENTS

TREATMENT OF EXPERIMENTAL DATA. By Archie G. Worthing and Joseph Geffner. John Wiley and Sons, New York, 1943: iii-ix, 1-342. $4.50.—Although this book was written primarily for chemists, physicists, and engineers, it is believed that it will be of interest to some biologists, since there are appearing in biological journals an increasing number of papers which indicate that the authors are analyzing their experimental data by methods similar to those in the exact sciences. For these workers the book may prove a valuable supplement to such standard texts as those of Fisher, Yule, Treloar, Ezekiel, Snedecor, et al.

The reviewer found the chapters on the representation of data by tables, graphs and equations to be especially good. These subjects are treated more thoroughly than in most statistical texts, bringing out many points of technique which ordinarily must be learned by experience. Methods presented will prove valuable in the analysis of data from the large class of experiments involving interdependent varying quantities.

The remainder of the book, aside from subjects of interest mainly to non-biological scientists, deals with familiar statistical topics, including frequency distributions, fitting of lines by least squares, and correlation analysis. To readers familiar with the authors mentioned above, the terminology will appear a bit strange, although the basic treatment follows conventional lines. It is noted with regret that the outmoded (in biology) measure "probable error" (.6745 times the standard error) is introduced as a "precision index," indicating that it is still in use in the physical sciences.

An explanation of the use of determinants, referred to frequently in the text, is given in one of the appendices. The book is not recommended to those not familiar to some extent with the methods of mathematical analysis.—R. P. SILLIMAN, *Stanford University, California.*

MANY HAPPY DAYS I'VE SQUANDERED. By Arthur Loveridge. Harper and Brothers, New York, 1944: XIV + 278, 19 halftone figs., $2.75.—Many readers of COPEIA will wonder at the author's choice of title for this story of a naturalist's life in England and Africa. His time, from his own account, seems to have been admirably well spent. Mr. Loveridge's product of scientific papers and the excellent order of the great collection of amphibians and reptiles in his charge at the Agassiz Museum further belie the word "squandered."

By no means the least interesting feature of books by naturalists lies in the insights to be gained into the origin and nature of the genus naturalist. To this naturalist his fellow creatures, human and non-human, and indeed, all the phenomena of nature, seem vastly more interesting and worthy of study than are personal advancement or pecuniary gain. The natural history of naturalists is best studied from their works. Thus the opening chapters of the present book, devoted to childhood collecting in England and Wales, are of especial interest.

The remaining chapters form a running account of the author's life in Africa as curator of the Nairobi Museum, a member of the East African Mounted Rifles, 1914–1918, and as Assistant Game Warden of Tanganyika Territory, closing with the year 1924. It is to be hoped that the subsequent twenty years as curator of amphibians and reptiles at the Museum of Comparative Zoology, with his fruitful collecting expeditions to Africa, may yield a companion volume.

It is difficult to convey the variety of incident in the African experience recorded. Indeed, the book suffers from a resultant monotony, since anecdote follows anecdote with little distinction between the trivial and the important, and no central theme to which the incidents contribute or on which they might throw light. Herpetologists will value the book especially for its accounts of the spitting cobras, of mamba catching, and of the discovery of the truly remarkable flattened land turtle that lives in rock crevices in East Africa.—KARL P. SCHMIDT, *Chicago Natural History Museum, Chicago 5, Illinois.*

THE CATFISHES OF VENEZUELA, WITH DESCRIPTIONS OF THIRTY-EIGHT NEW FORMS. By Leonard P. Schultz. Proc. U. S. Nat. Mus., 94, 1944: 173–338, 14 pls., 5 figs., 28 tab.—It is a pleasure to encounter a paper on South American ichthyology in which the author has tried to make his work complete and useful. Dr. Schultz' account of the catfishes of Venezuela is such a paper. It is handicapped, as all work on South American ichthyology must be at present, by a lack of comprehensive comparative material, thus necessitating a large amount of compilation from literature. This is no adverse criticism. But it does seem undesirable under such circumstances to follow Dr. Schultz in undertaking a complete trinomial nomenclature for neotropical fishes. Such a procedure should certainly await a wider knowledge of the subject.

The following systematic suggestions may also be noted. In the key to the families of catfishes (pp. 181–82), the Callichthyidae, with a reverted lower lip, falls in the section under "lower lip not reverted or folded back to form a disklike mouth." Though the callichthyid mouth is not "disklike," that would hardly be clear to those, to whom the key is primarily useful, who do not know the Venezuelan families of catfishes already. In the same key the Astroblepidae are stated to be "with plates" when without plates was undoubtedly intended. The use of the family name Bagreidae throughout instead of the more usual Ariidae leads to confusion with the Bagreidae, an entirely different family of catfishes. The genus for which Dr. Schultz uses the name *Hypostomus* (pp. 286 and 320) should be called *Plectostomus*, as I recently pointed out (COPEIA, 1942: 41).

Two points about the paper are slightly disconcerting. One is the complete unpronounceability of some of the new names proposed. Secondly, since almost all of the specimens reported upon were collected by the author, it seems vaguely pompous as well as superflous to have "Leonard P. Schultz" cited 55 times as the collector.

Be these things as they may, I hope Dr. Schultz will deal with the remainder of his Venezuelan collections in the same thorough manner that he has dealt with the catfishes.—W. A. GOSLINE, *Museu Nacional, Rio de Janeiro, Brazil.*

THE COREGONINE FISHES OF NORTHWESTERN CANADA. By John R. Dymond. Trans. Roy. Can. Inst., 24, pt. 2, 1943: 171–232, fig. 1.—In this study Dymond pays particular attention to the relationship between the fish faunas of northwestern North America and of northern Asia, treating in detail the Coregonidae, which dominate the waters that flow into the Arctic. Considerable divergence of opinion in regard to the relationship has developed. Some have held to the older view that the American species are all distinct. Others have regarded a large proportion of the American forms as specifically identical with those of Asia. Dymond's views, derived by a judicious consideration of the published and original evidence, strike a compromise between the extreme opinions. The nominal northwestern species of *Coregonus* are treated as subspecies of *C. clupeaformis*, but this species is regarded as the obvious New World representative of *C. nasus*. The subspecies of *Prosopium cylindraceum* seem to form a cline from northern Asia to the Great Lakes. The nominal species of *Leucichthys* in northwestern Canada are considered at length. *L. artedi* is held to range widely over the northwest. The forms named *macrognathus, athabascae* and *entomophagus* are relegated to the synonymy of *L. zenithicus*. Two species, *L. autumnalis* and *L. sardinella*, are regarded as common to Asia and Canada. All forms of *Stenodus*, in both continents, are recognized as subspecies of *S. leucichthys*. Certain specimens are plausibly interpreted as natural hybrids between *Stenodus* and *Leucichthys*. Dymond has laid the foundation for a much clearer understanding of a problem of large importance in ichthyology and in zoogeography.—CARL L. HUBBS, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

THE FISHES OF MANITOBA. By David Hinks. Department of Mines and Natural Resources, Winnipeg, 1943: X + 100.—"The Fishes of Manitoba" is another volume adding to the fast growing body of popular handbooks on North American fishes. Excellent keys to the species occurring in the Province are given, together with drawings, and, whenever knowledge permits, brief life history notes. Essays on anatomy, classification and identification of fishes are included.—L. A. WALFORD, *Stanford University, California.*

THE CHEMISTRY AND TECHNOLOGY OF FOOD AND FOOD PRODUCTS. Vol. 1. Edited by Morris B. Jacobs.—Interscience Publishers, Inc., New York, N. Y., 1944: i–XV, 1–901, 217 tables, 79 figs. $10.50.—This is the first of a two volume collection of papers, prepared by 41 collaborators, on various phases of the chemistry and technology of food and food products. The plan of the work is in six parts: The first, on fundamentals, deals with the aspects of food chemistry which are common to all foods. The second part concerns the descriptive aspects of particular food groups and includes some account of the history, statistics, definitions, standards, composition, and chemistry of these food groups. In part three, unit operations and processes applicable to most foods are described. Part four deals with the maintenance of sanitary and quality control of foods and food products. In part five, the principal methods of preserving foods are delineated. Part six is concerned with production methods for the principal foods. Throughout the entire book, the rôle played by adequate nutrition in modern life is stressed. Chapter 14 (pp. 473–521), by Maurice E. Stansby, of the Fish and Wildlife Service, is an excellent, brief review of the fishery industries of the United States. It discusses methods of fishing as well as of handling fish, and includes a number of valuable tables giving the mineral, oil, vitamin, and nutritative composition of various kinds of fish and fishery products.—L. A. WALFORD, *Stanford University, California.*

MARINE ALGAE OF THE MONTEREY PENINSULA, CALIFORNIA. By Gilbert M. Smith. Stanford University Press, 1944: VII + 609, 98 plates.—For the past seventeen years, Dr. Gilbert Smith, of Hopkins Marine Station, has collected seaweeds in the region of Monterey, California. On the basis of this material, he has written new descriptions, constructed keys to the orders, families, genera and species and made a profuse number of beautiful drawings. This book is the product of that work. It is an excellent example of a particularly difficult subject presented in a clear, simple manner; a fact for which non-botanical marine biologists will be grateful to the author.

Although the area covered by the scope of this book may seem limited, it is peculiarly rich in marine flora as well as fauna. Over 80 percent of the seaweeds to be found anywhere between Puget Sound and Southern California occur there; and it is the type locality of about a quarter of the species occurring in that range of coast. The book thus has a much wider application than that indicated by its rather modest title.—L. A. WALFORD, *Stanford University, California.*

EDITORIAL NOTES AND NEWS

Honor Roll

ADDITIONS to and changes in the list of Society members in the U. S. armed services are: PVT. ANTON F. BAARSLAG, U. S. Army; CPL. DAVID BIERHORST, U. S. Army; PVT. KENNETH H. DOKE, U. S. Infantry; LT. HAROLD TRAPIDO, Army Medical Corps; E. M. 2-C. JOHN WERLER, U. S. Coast Guard.

1ST. LT. ALBERT G. SMITH, Army Air Force, has recently returned from combat duty with the 8th Air Force in England. He holds the Air Medal with three Oak Leaf Clusters and the Distinguished Flying Cross. He has been assigned to the Tropicalization Unit of the Materiel Command, Wright Field, where he will be engaged in research problems. Lt. Smith was formerly with the Biology Department of the University of Pittsburgh.

News Notes

DR. ETHELWYNN TREWAVAS, of the British Museum, writes that she has now nearly finished copy for the Pisces section of the "Zoological Record" for 1942 and 1943 and hopes that it will be printed soon. She reported in July that "The Museum lost quantities of glass by blast last Wednesday, and yesterday a bomb fell in the road just outside and caused even worse damage, especially to the bird and mammal exhibition galleries. The specimens are relatively unhurt. The study collections were untouched except a drawer of butterflies on which someone was working at the time. Casualties among the staff were few and light, none fatal."

Of 37 zoologists, newly honored by stars in the seventh edition of American Men of Science, 7 are members of this Society. The recipients of this well-deserved recognition, to whom go the congratulations of their fellow members, are: CHARLES M. BREDER, JR., LEE D. DICE, EMMETT R. DUNN, MYRON GORDON, PETER OKKELBERG, KARL P. SCHMIDT, and C. L. TURNER.

DR. CARL L. HUBBS, for the past 24 years Curator of Fishes in the Museum of Zoology, University of Michigan, has resigned to accept the position of Professor of Biology in Scripps Institution of Oceanography, of the University of California at La Jolla.

JOHN R. NORMAN, Deputy Keeper in the British Museum (Natural History), and Honorary Foreign Member of our Society, died on May 26, at the age of 45.

DR. G. E. POTTER, of the Agricultural and Mechanical College of Texas, has been granted a leave of absence to join the staff of the College of Agriculture and Mechanical Arts at the University of Puerto Rico, at Mayaguez, as visiting Professor of Biology.

DR. EMMELINE MOORE, recently retired Chief Aquatic Biologist and Director of the Biological Survey for the New York State Conservation Department, has been appointed Research Assistant in the Bingham Oceanographic Laboratory at Yale University for the academic year 1944–45. She is engaged in work on the program involving studies on the utilization of marine resources undertaken by this laboratory in cooperation with the Connecticut State Board of Fisheries and Game and the Woods Hole Oceanographic Institution.

DR. REEVE M. BAILEY, Assistant Professor of Zoology and leader of the Iowa State Fisheries Research Unit of Iowa State College, has resigned to join the staff of the Museum of Zoology, University of Michigan, as Associate Curator in charge of the Fish Division.

Members experienced in the maintenance of laboratory stocks of fishes and amphibians may wish to correspond with ALASTAIR N. WORDEN, Institute of Animal Pathology, University of Cambridge, England. Dr. Worden is editor of a handbook on the care and management of laboratory animals, which is being compiled by the Universities Federation for Animal Welfare. For further description of the projected volume see Science, July 28, 1944: 76.

DR. L. C. STUART, of the Museum of Zoology, University of Michigan, is making a reconnaissance and collecting trip during September and October to the Montagua Valley and the interior desert basins of Guatemala.

Aid in printing the article on "Species of the Circumtropical Fish Genus *Brotula*," in this issue, has been furnished by the SPECIAL GIFT FUND of the Society.

Request

HERPETOLOGISTS having duplicate copies of original descriptions of American salamanders (north of Mexico) are asked to contribute them for the purpose of building up a complete list for lithoprinting. Copies received which duplicate those already on hand will be returned.—SHERMAN C. BISHOP, *Biological Laboratories, University of Rochester, Rochester, N. Y.*

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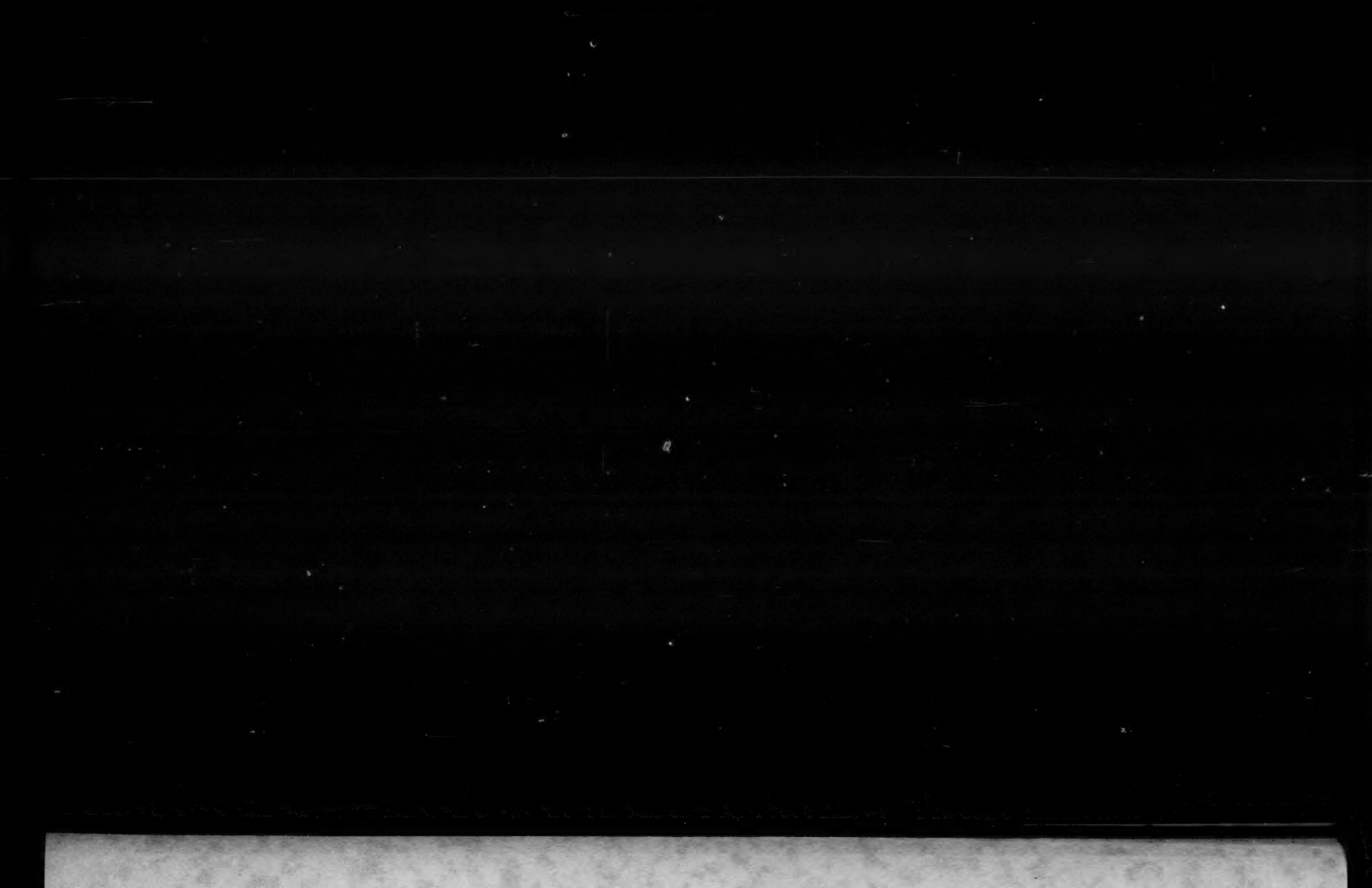
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